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GROUND WATER IN REESE RIVER BASIN AND ADJACENT PARTS OF HUMBOLDT RIVER BASIN, NEVADA

BY

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GROUND WATER IN REESE RIVER BASIN AND ADJACENT PARTS OF HUMBOLDT RIVER BASIN, NEVADA.

By Gerald A. Waring.

INTRODUCTION.

GROUND WATER FOR IRRIGATION IN NEVADA.

One of the remarkable achievements in the winning of the West has been the development of great areas of tillable land into a multitude of farms within the last half century. In the last decade, however, Government land that is suitable for farming and open to entry has become scarce because of the rapid homesteading in the desirable areas. The realization by prospective homesteaders that lands suitable for farming are becoming scarce has apparently served as a stimulus to settlement, and many entries have been made on lands that are unsuitable for farming.

In Nevada the mountains lie in approximately parallel ranges that trend in general nearly north, and the valleys between them are deeply underlain by gravel, sand, and clay, brought down by flood water from the bordering mountain slopes. This unconsolidated valley fill serves as a great reservoir in which much of the water that falls as rain or snow becomes stored as ground water, and in some valleys in Nevada this water is available for irrigation by means of wells and pumping plants.

At some places, however, the ground water is too alkaline for successful use in irrigation, or it lies at a depth so great that the cost of pumping would be excessive, or it can not be developed in amount sufficient to make its use economically successful. It is therefore important that the ground-water conditions be carefully studied before agricultural settlement is attempted.

INVESTIGATION OF GROUND WATER IN REESE RIVER BASIN.

As a continuation of the United States Geological Survey's studies of ground water in Nevada the writer was assigned to make an examination of the drainage basin of Reese River and adjacent parts of the basin of Humboldt River, in the central part of the State (see Pl. VII), and spent the month of September, 1916, in this study, in company with Ernest L. Neill, of Stanford University. Acknowledgment is due to Mr. Neill for able assistance rendered and to many ranchmen for hospitality and for information furnished.

GEOGRAPHY OF THE AREA.

Reese River flows in a nearly direct course a little east of north from its headwaters in the Toyabe Range to its junction with Humboldt River. It is about 150 miles long, and its drainage basin is 12 to 30 miles wide. The valley occupies, at most places along its course, hardly one-third of the width of the drainage basin, and in its middle part it is constricted to form the Reese River canyon. (See Pl. VIII, in pocket.) Antelope Valley and Buffalo Valley are connected with the valley of Reese River by broad lowlands. In each of these tributary valleys the storm waters gather in a playa which is dry most of the year but in wet seasons forms a lake or expanse of alkali-incrusted mud. These playas rarely overflow to Reese River.

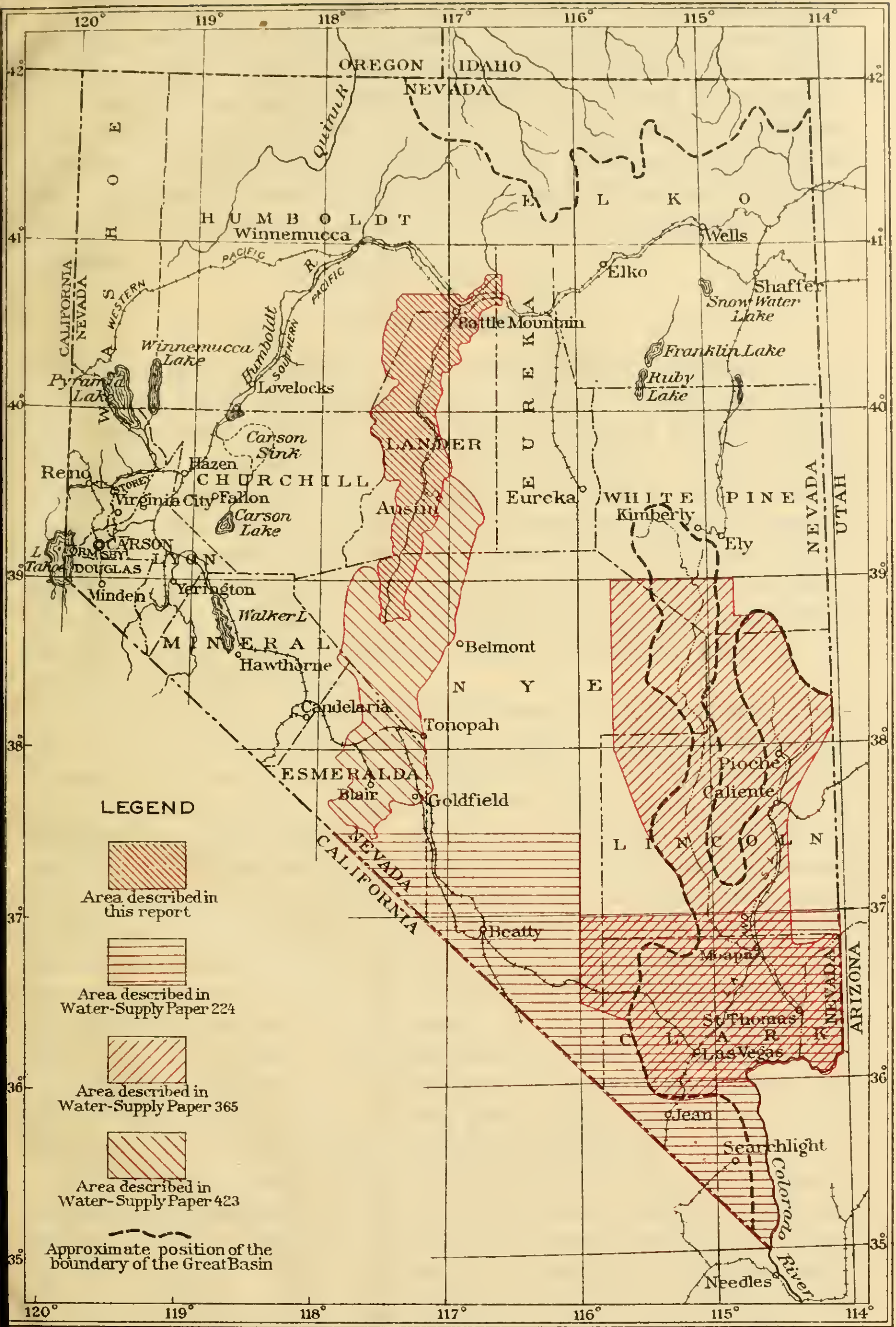
From an elevation of about 7,400 feet in Indian Valley, at the south end of the basin, the valley descends at a fairly uniform grade northward along Reese River to an elevation of only 4,500 feet at the junction of Reese River with the Humboldt. The principal peaks in the mountains that border the northern and central parts of the basin are 7,000 to 9,000 feet above sea level. To the south the crest of the Toyabe Range is for the most part more than 10,000 feet above the sea, and Arc Dome, the culminating point of the range and of the rim of the drainage basin, has an elevation of 11,775 feet.

The climate of the area is arid. The average annual precipitation at Battle Mountain is about 7 inches; at Austin it is about 12½ inches, and in the higher mountains it may reach 20 inches. About half the precipitation falls in December to March, inclusive. July is usually the driest month of the year. In the mountains the precipitation is mainly in the form of snow; in the valleys the irregular summer rains usually come as thunderstorms.

Because of the dryness of the air and the relatively great elevation of the region above sea level, the daily range in temperature is great. It is said that in the southern part of the Reese River valley frosts may occur in any month of the year. The mean annual temperature is about 50° F.

The area is sparsely populated. In 1910, according to the census, Austin had a population of 700 and Battle Mountain 475. These are the only two towns in the area examined.

Austin (see Pl. IX, *A*) was formerly an important mining town, and soon after silver was discovered there, in May, 1862, it contained several thousand people. Of late years, since the principal mines were closed, it has served chiefly as a supply point for prospectors and ranchers and, as it is on the Lincoln Highway, for automobilists. It is connected with the Southern Pacific Railroad at Battle Mountain by the Nevada Central Railroad, a narrow-gage line 103 miles long.



MAP OF NEVADA SHOWING AREAS COVERED BY THE PRESENT AND OTHER WATER-SUPPLY PAPERS OF THE UNITED STATES GEOLOGICAL SURVEY

1918

25 0 25 50 75 100 Miles

Battle Mountain is a shipping point for live stock and a supply and shipping point for mining interests. In 1916 there were small settlements at the mining camps of Galena and Copper Canyon, to the southwest, and at Lewis, Dean, Maysville, and Hilltop, to the southeast. The remainder of the inhabitants of this area live chiefly on the scattered ranches in the valley. These ranches are devoted to the raising of live stock, principally cattle. Native hay is extensively grown for winter feeding, and alfalfa also is raised on several ranches.

PHYSIOGRAPHY.

MOUNTAINS.

The southern part of the Reese River valley is bordered on the east by the Toyabe Range and on the west by the Shoshone Range. The river crosses to the west side of the Shoshone Range through Reese River canyon and thence flows northward. North of the canyon the east side of the river basin is formed by the Shoshone Range and the west side of the basin is bordered by parts of several ranges—the Desatoya Mountains at the south end of Antelope Valley, the Augusta Mountains on its west side, the Fish Creek Mountains along its north end, and the Havallah Range along the west side of Buffalo Valley. Battle Mountain forms a detached mass at the north end of Buffalo Valley.

The Toyabe Range is the highest of these ranges, containing peaks that rise more than 4,000 feet above the valley. The range as a whole is narrow and has a short, steep eastern front and longer, less precipitous western slopes. This form seems to have been produced by faulting and uplift along the east side of the range. Although this range is narrow and its slopes are in general steep, prolonged erosion prior to the uplift that gave it its present form produced undulating valleys and smoothed and rounded the summits in its higher parts.[1] These upland valleys form small areas of grazing land, where the grass keeps green well into the summer. Indian Valley (see Pl. X, *B*) probably acquired approximately its present form during this early erosional period. The most prominent rounded summit of the range is Mount Callahan, or "The Dome." From Reese River valley the Toyabe Range rises in a long, gentle slope that extends to its very top, but on its east side the slope is precipitous.

The Shoshone Range (called the Reese River Range by Spurr[2]) seems to be essentially anticlinal in structure, though its steepest fronts, notably those near Smith Canyon, have probably been produced by faulting. The hot springs in the lowlands a few miles south-

[1] Meinzer, O. E., Geology and water resources of Big Smoky, Clayton, and Alkali Spring valleys, Nev.: U. S. Geol. Survey Water-Supply Paper 423, pp. 18–22, 1917.

[2] Spurr, J. E., Descriptive geology of Nevada south of the fortieth parallel and adjacent portions of California: U. S. Geol. Survey Bull. 208, p. 97, 1903.

west of this canyon are presumably supplied by deep-seated water that rises along fault lines. The range seems to have been uplifted since the Reese River drainage system was established, and the stream has apparently maintained its course by cutting down through the rocks as fast as they were uplifted, in a way similar to that in which Yakima River in central Washington [1] and other rivers have cut gorges across lava ridges. Throughout the canyon the alluvium is several feet deep. Cutting apparently has ceased, and some filling of the canyon has taken place. Similar filling is well shown by Boone Creek. (See Pl. XI, *A*.)

The mountains and ranges along the west side of the northern half of the Reese River basin seem to be in general anticlinal in structure, though detailed study would probably show considerable faulting. Battle Mountain forms a detached mass whose sedimentary strata dip in the main westward, and early studies indicated that this mass may be an extension of the anticline of the Shoshone Range.[2]

ALLUVIAL FANS.

Extensive alluvial fans have been built out from the mouths of the numerous canyons on each side of the valley, and the larger of these fans continue, well defined but with gentler slopes, down to the lowlands along the river. The alluvial fan near the mouth of Big Creek (see Pl. X, *A*) is especially prominent, though it has been deeply dissected by the creek.

BLUFFS.

Unconsolidated sedimentary beds are exposed for considerable distances along the borders of the lower lands, and in several places they form prominent bluffs. The bluffs along the valley near Boone Creek (see Pl. IX, *B*) are carved in such materials. There are similar bluffs on the west side of the valley, opposite Austin, and also 40 miles farther south, on the east side of the valley, near the Schmaling ranch.

PLAYAS.

The principal playas ("dry lakes" or alkali flats) in the drainage basin of Reese River are in Antelope and Buffalo valleys. The one in Antelope Valley has an area of only about 1 square mile, and it has an overflow channel that runs northward and eastward to Reese River. The one in Buffalo Valley is nearly 5 miles long from northeast to southwest and about 2 miles wide. During exceptionally wet seasons it may discharge northeastward to Reese River, but no outlet channel was noticed.

[1] Smith, G. O., U. S. Geol. Survey Geol. Atlas, Ellensburg folio (No. 86), p. 5, 1903.

[2] Hague, Arnold, and Emmons, S. F., U. S. Geol. Expl. 40th Par. Rept., vol. 2, p. 667, 1877.

Along the lower course of Reese River there are extensive areas of poorly drained alkali land from which the spring flood water evidently runs off very slowly, but no depressions were observed where intermittent lakes may form.

GEOLOGY.

GEOLOGIC SKETCH.

The geologic history of the Reese River region is believed to be in brief as follows: [1]

During Paleozoic and Mesozoic time the greater part of the region was submerged, and extensive deposits of limestone, sandstone, and shale were formed. The Reese River basin is geographically in a transition zone between the higher plateau lands of eastern Nevada and the lower lands farther west. Geologically, also, the basin is in a transition zone, for all the ancient sedimentary rocks along its east side are of Paleozoic age, whereas those on the west are of Mesozoic age.[2]

The evidence indicates that during the Paleozoic era an extensive area east of the Reese River basin was submerged, whereas the land for many miles westward stood above sea level. With the ending of the Paleozoic and the beginning of the Mesozoic era the conditions were reversed, the western region being submerged and the eastern region uplifted. Since the Mesozoic era central Nevada as a whole has been uplifted several thousand feet above sea level by widespread structural movement, and the present mountain ranges have been developed by both transverse and longitudinal stresses.[3]

The sedimentary rocks in the ranges bordering the Reese River valley have been intruded by granitoid rocks, which constitute the cores of the mountains.

During the Tertiary period large areas, including perhaps the greater part of the basin of Reese River, were occupied by extensive fresh-water lakes, in which beds of gravel, sand, and clay were deposited, together with layers of volcanic ash. After this lake period, probably in the Miocene epoch of the Tertiary, great floods of lava were poured out through numerous fissures or other centers of extrusion in the mountain ranges and buried deeply a large part of the Paleozoic and Mesozoic sedimentary rocks, as well as the Tertiary lake deposits. After this period of extrusive activity the region was much disturbed by crustal movements, and the principal mountain ranges, which were originally in the main anticlinal,

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[1] For detailed discussions of the rocks and the geologic structure, see Hague, Arnold, and Emmons, S. F., U. S. Geol. Expl. 40th Par. Rept., vol. 2, pp. 615-688, 1877. For description of the mining districts see Hill, J. M., Some mining districts in northeastern California and northwestern Nevada: U. S. Geol. Survey Bull. 594, pp. 64-125, 1915.

[2] King, Clarence, U. S. Geol. Expl. 40th Par. Rept., vol. 1, p. 412, 1878.

[3] King, Clarence, U. S. Geol. Expl. 40th Par. Rept., vol. 3, p. 325, 1870.

were profoundly faulted and tilted, so that their structure is now complex.

More recently the mountains have been extensively eroded, and the rock waste has been deposited in the lower parts of the basin. Reese River has cut its canyon across the Shoshone Range since the lavas were poured out, presumably in large part during Pliocene and Pleistocene time. During the Pleistocene epoch a perennial lake is believed to have occupied Buffalo Valley.[1]

PALEOZOIC SEDIMENTARY ROCKS.

The Paleozoic sedimentary rocks consist of limestone, slate, and quartzite and were probably laid down throughout the Paleozoic era. They are exposed over extensive areas in the Toyabe and Shoshone ranges and in Battle Mountain (see Pl. VIII, in pocket) but not west of these ranges. The change in conditions of deposition (see p. 99) apparently accounts for the absence of Paleozoic sediments from the region west of Battle Mountain and the Shoshone Range.

MESOZOIC SEDIMENTARY ROCKS.

Limestone, shale, and sandstone that contain Mesozoic fossils form the Havallah Range along the west side of Buffalo Valley. Small exposures along the flanks of the Fish Creek, Augusta, and Desatoya mountains indicate that the Mesozoic rocks also compose the mass of these mountains beneath the thick sheets of lava that lie at the surface.

PRE-TERTIARY CRYSTALLINE ROCKS.

Areas of crystalline rocks, chiefly granitoid, are exposed along the crest of the Toyabe Range in the vicinity of Austin and near Mount Beseler, 40 miles to the south. Granite and diorite form the summit of Ravenswood Peak, in the Shoshone Range, and the crest of the range for about 10 miles south of this peak is formed of granite bordered by a narrow zone of crystalline schist. In the northern part of the range Shoshone Peak and adjacent areas are composed of granodiorite and other granular rocks.[2]

Along the west side of the basin granitoid rocks make up the north end of the Havallah Range; and exposures beyond the Reese River basin, along the flanks of the Fish Creek and Augusta mountains, indicate that the cores of these ranges also are composed of granitoid material. Small areas of diorite were mapped by the Fortieth Parallel Survey on the east slope of New Pass Mountain and in the Havallah Range.[3]

[1] See U. S. Geol. Expl. 40th Par. Atlas, map 5, 1876.

[2] Emmons, W. H., A reconnaissance of some mining camps in Elko, Lander, and Eureka counties, Nev.: U. S. Geol. Survey Bull. 408, pl. 5, 1910.

[3] U. S. Geol. Expl. 40th Par. Atlas, map 5, 1876.

OF AUSTIN.

EEK.

A. VIEW LOOKING WESTWARD ACROSS REESE RIVER VALLEY FROM SLOPES BACK OF AUSTIN.

B. LOW BLUFFS ALONG REESE RIVER VALLEY NEAR MOUTH OF BOONE CREEK.

The ancient crystalline rocks of the Toyabe Range are intrusive in the Paleozoic rocks and are regarded by Hill[1] as of late Cretaceous or possibly of early Tertiary age. With the exception of the schists south of Ravenswood Peak that have been classed as Archean,[2] the crystalline rocks of the Shoshone and Havallah ranges are probably also intrusive in the Paleozoic and Mesozoic sedimentary rocks.

TERTIARY LAKE BEDS.

Around the border of Antelope Valley and in the Reese River valley upstream from the Reese River canyon the Tertiary lake beds are exposed at many places beneath the lava (see Pl. XII, *A* and *B*) or the overlying alluvium. These beds were early classed as Miocene and named the Truckee group.[3]

In Antelope Valley and in the vicinity of Italian and Silver creeks and the Reese River canyon the beds are composed chiefly of sand and clay but include considerable volcanic ash. Associated with the unconsolidated materials west of Austin there are beds of hard calcareous sandstone, which were also referred to the Truckee by the geologists of the Fortieth Parallel Survey. South of the area examined by these geologists there are prominent bluffs of light-colored sediments. In the vicinity of Schmaling's ranch (see Pl. VIII, in pocket) and near Warner's ranch there are deposits of coarse gravel consisting chiefly of well-rounded fragments of lava. These deposits have been shown on Plate VIII as belonging to the Truckee formation, but they may prove on detailed study not to be of this formation.

TERTIARY LAVAS.

The lavas of the Reese River basin are chiefly rhyolites, but small areas of andesites, trachytes, and basalts were mapped by the Fortieth Parallel Survey.[4] The basaltic rocks seem to be the most recent in age. On the east side of Buffalo Valley there are two well-formed volcanic cones built up chiefly of trachyte, but the last material ejected from their craters is basaltic. In the Humboldt Basin, on the east border of Shoshone Mesa 1 or 2 miles south of the canyon of Rock Creek, basalt has been poured out over rhyolite, which is the prevailing rock, and the black color of the later flows contrasts with the prevailing red and brown tones of the earlier rock.

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[1] Hill, J. M., Some mining districts in northeastern California and northwestern Nevada: U. S. Geol. Survey Bull. 594, p. 99, 1915. S. F. Emmons (U. S. Geol. Expl. 40th Par. Rept., vol. 3, p. 324, 1870) considered these rocks to be intrusive and hence of later age than the Paleozoic sediments; but King (idem, vol. 1, p. 75, 1878) seems to have believed them to be Archean and hence to underlie the Paleozoic deposits.

[2] Hague, Arnold, and Emmons, S. F., U. S. Geol. Expl. 40th Par. Rept., vol. 2, p. 636, 1877.

[3] King, Clarence, U. S. Expl. 40th Par. Rept., vol. 1, p. 414, 1878. Emmons, S. F., idem, vol. 2, p. 639, 1877.

[4] U. S. Geol. Expl. 40th Par. Atlas, maps 4 and 5, 1876.

QUATERNARY DEPOSITS.

The lands in the valleys of Reese and Humboldt rivers are underlain by deposits of alluvium which drilled wells have penetrated for depths of several hundred feet without reaching solid rock. In Buffalo Valley the geologists of the Fortieth Parallel Survey distinguished the finer-grained deposits of the playa, which they called "Lower Quaternary" from the prevailingly more sandy deposits in the rest of the basin, which they called "Upper Quaternary," but these deposits are now known to be of approximately the same age.

Records of drilled wells indicate that throughout the Reese River basin the deposits in the lower lands are clayey rather than sandy. The extensive alluvial fans and slopes that border the lowlands contain much gravel and angular fragmental material, but the valley fill seems to be in large part fine grained and derived from the lake beds composing the Truckee formation. On the west side of the valley, opposite Austin, the Lincoln Highway crosses Quaternary deposits derived from the Truckee beds. In the fall of 1916 the road had become greatly cut up by automobile traffic, which rapidly wore deep ruts into the flourlike material.

PRECIPITATION.

Records of precipitation have been kept by the United States Weather Bureau at Austin (elevation 6,600 feet above sea level) and at Battle Mountain (elevation 4,500 feet). Although the records are not complete for every year since the beginning of observations, a

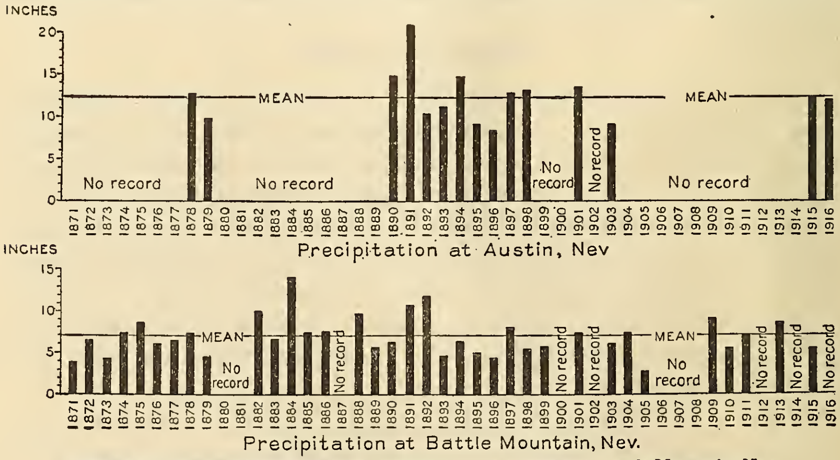
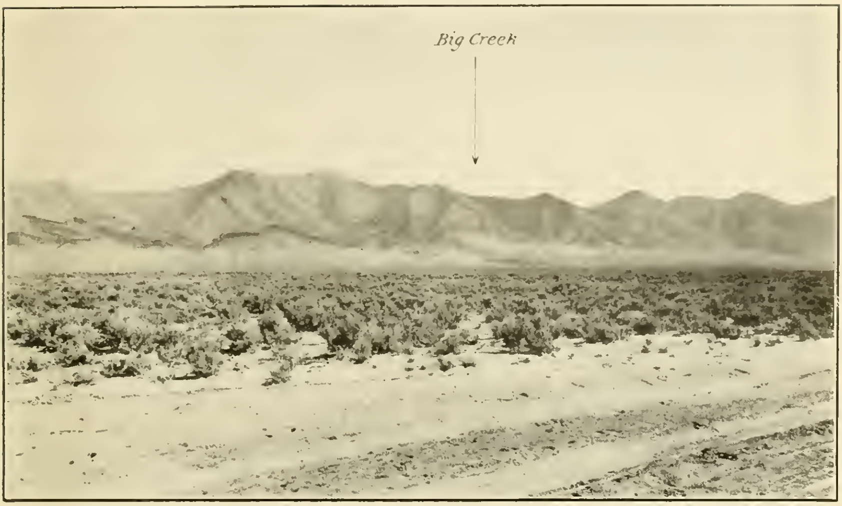


FIGURE 4.—Diagram showing annual precipitation at Austin and Battle Mountain, Nev.

sufficient number of records are available to show that the mean annual precipitation is about 12½ inches at Austin and 7 inches at Battle Mountain. The monthly and annual records are given in the following tables, and the annual totals are shown graphically in figure 4.



A. ALLUVIAL SLOPES NEAR MOUTH OF BIG CREEK, LOOKING SOUTHEASTWARD.

B. INDIAN VALLEY, LOOKING NORTHWARD FROM ITS HEAD.

Precipitation, in inches, at Austin, Nev., 1878-1916.[a]

[No records for 1881-1887, 1899, 1909, 1910.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1878	0.51	1.49	2.08	1.37	1.56	1.52	0.15	1.31	0.85	0.82	0.99	0.12	12.77
1879	2.13	.58	.43	1.45	.46	1.15	.02	Tr.	Tr.	.85	.85	1.88	9.80
1880	.34	1.25	1.08	2.92	.56	.01	.11	.11	.20	......	......	......	......
1888	......	.30	......	.25	......	Tr.	.09	......	1.00	......	.60	......	......
1889	.60	......	......	......	.25	......	0	0	......	......	.54	2.66	......
1890	3.64	1.82	2.98	1.26	1.48	.05	.30	1.16	.45	.61	.10	1.10	14.95
1891	.45	1.77	2.01	2.31	3.81	2.64	1.26	1.09	.85	.34	.23	4.31	21.07
1892	.63	.56	1.72	1.34	1.90	1.47	.07	Tr.	.18	.24	.40	1.92	10.43
1893	1.22	1.39	1.72	2.86	.88	0	1.02	.60	.32	.07	.55	.59	11.22
1894	1.39	1.89	1.63	1.82	.85	2.44	1.27	.50	.33	0	Tr.	2.77	14.89
1895	1.43	1.29	.49	.61	2.66	.05	Tr.	.14	Tr.	.51	1.04	1.00	9.22
1896	1.39	.05	1.30	1.41	1.76	.13	.85	.58	.39	0	.41	.18	8.45
1897	1.30	2.11	1.79	.94	.61	.79	.39	.38	.07	2.76	.55	1.20	12.89
1898	1.60	.27	1.43	1.16	4.18	.05	.40	.56	.30	.24	1.88	1.14	13.21
1900	......	......	......	2.09	1.20	.63	.79	Tr.	.15	1.03	.86	.09	......
1901	1.24	4.14	.49	.15	2.02	.05	.51	1.84	.22	1.79	.88	.40	13.73
1902	.43	1.10	1.51	1.18	.98	0	.48	.32	.34	......	1.26	.39	......
1903	1.80	.49	2.40	1.91	1.57	.60	0	.30	Tr.	0	.04	.13	9.24
1904	1.01	2.22	.88	1.98	1.21	.05	.31	1.13	3.03	......	Tr.	.88	......
1905	.70	......	1.51	.91	.99	.03	.03	......	......	......	......	.73	......
1906	.31	......	......	2.56	2.50	1.28	.23	.97	.60	.30	1.41	1.83	......
1907	1.74	......	......	......	......	......	......	.02	.91	.36	1.00	2.62	......
1908	1.55	1.30	1.55	1.03	1.41	......	......	......	......	......	......	......	......
1911	1.30	2.70	1.50	.26	1.12	.01	......	.05	0	......	.12	.84	......
1912	.50	......	2.00	......	......	......	......	.65	......	1.60	.40	.60	......
1913	.95	.15	.97	2.00	......	2.86	1.60	2.70	.48	.30	......	......	......
1914	......	......	......	......	......	......	......	.13	.29	.56	0	.21	......
1915	1.26	.74	.94	4.54	2.21	0	.14	.41	.81	.02	.01	1.31	12.39
1916	2.63	.96	1.48	.72	.22	0	.01	Tr.	1.28	3.39	.80	.50	11.99
Mean of the 15 complete records													12.41

[a] U. S. Weather Bur. Bull. W, section 12, p. 2.

Precipitation, in inches, at Battle Mountain, Nev., 1870-1916.[a]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1870	......	......	......	0.05	0.30	0.77	0	0	0	0.30	0.59	0.13	......
1871	0.12	0.22	0.37	.38	.65	.04	.47	0	0	.41	.26	.95	3.87
1872	0	.20	.43	1.00	1.19	1.00	.50	0	1.31	.01	.02	.83	6.49
1873	.10	2.10	.19	.05	.49	0	0	.02	.04	.05	.07	1.20	4.31
1874	.95	1.56	1.07	.21	.40	0	.25	.80	0	1.38	.65	.15	7.42
1875	2.57	.25	.60	.05	.90	0	0	.10	.06	.75	2.45	.93	8.66
1876	.40	.30	1.05	.75	.24	.27	.53	0	.60	.53	1.21	.12	6.00
1877	2.20	.53	2.07	.30	1.04	0	.20	0	0	.03	.40	0	6.77
1878	.29	1.02	.44	.64	2.17	1.24	0	.90	.15	.31	.23	0	7.39
1879	.65	.25	.16	.63	.45	.82	0	0	.08	.15	.46	.85	4.50
1880	.08	.90	......	.59	.35	0	Tr.	0	0	0	Tr.	2.07	......
1881	1.23	.76	.45	.86	......	.28	0	.15	.16	.60	.56	1.03	......
1882	1.58	.70	2.10	1.27	.55	.83	.08	0	1.33	1.08	.15	.30	9.97
1883	.86	.70	.60	1.12	1.27	.23	Tr.	Tr.	0	.85	.70	.42	6.75
1884	.70	2.30	1.04	1.54	1.29	2.18	0	.10	1.12	1.94	0	1.82	14.03
1885	.55	1.48	.16	2.20	.61	.44	0	.33	0	0	.72	.91	7.40
1886	1.30	.10	.27	1.72	.24	.21	.38	0	.18	1.20	1.50	.44	7.54
1887	.73	1.15	.30	1.24	.14	.50	.12	.18	......	0	1.10	1.50	......
1888	3.12	.30	.25	.35	1.50	.51	.22	0	.65	.18	.82	1.89	9.79
1889	.60	0	1.16	.45	.64	.23	0	0	0	1.55	0	1.04	5.67
1890	2.55	.50	.81	.95	.25	0	0	.90	0	0	0	.30	6.26
1891	.10	.75	.50	1.60	1.93	1.87	.17	0	0	.10	.25	3.52	10.79
1892	.32	.58	2.18	2.55	2.35	1.82	0	0	.11	.35	.68	.83	11.77
1893	1.42	.10	.73	1.18	.12	.10	.30	0	.25	.05	.25	.10	4.60
1894	.38	1.25	.28	.40	1.25	1.15	.50	0	.10	Tr.	0	1.15	6.46
1895	.95	1.65	.10	.30	.50	0	.15	0	.10	0	.37	.92	5.04
1896	.60	.10	.85	.55	.90	0	0	0	0	.18	.85	.20	4.23
1897	.69	1.66	.54	.36	.35	1.22	0	0	0	1.90	.45	.91	8.08
1898	.47	.06	.55	.26	2.93	0	0	0	.50	.10	.32	.27	5.46
1899	Tr.	Tr.	2.23	.20	.50	1.25	Tr.	.81	0	Tr.	0	.75	5.74
1900	Tr.	.20	.10	......	.64	......	0	0	0	......	......	0	......
1901	.70	3.70	0	.86	0	0	0	.13	.68	.25	.45	.60	7.37

[a] U. S. Weather Bur. Bull. W, section 12, pp. 2-3

Precipitation, in inches, at Battle Mountain, Nev., 1870–1916 [a]—Continued.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1902	0.40	0.68	0.85	......	0.25	0	0.80	0.10	0.19	0.10	0.70	0	......
1903	1.35	.20	.92	0.30	.40	.34	0	0	0	.60	.90	1.10	6.11
1904	1.10	1.72	.60	.50	.75	Tr.	Tr.	Tr.	1.17	1.55	Tr.	Tr.	7.39
1905	Tr.	.40	.28	Tr.	.12	Tr.	0	.15	.10	.05	1.00	.70	2.80
1906	.90	......	......	......	......	.45	0	Tr.	0	Tr.	.50	......	......
1907	......	.03	.61	......	Tr.	Tr.	......	.05	1.50	1.00	0	2.05	......
1908	.47	.90	.04	1.75	.83	......	.09	0	1.00	......	Tr.	0	......
1909	2.40	.67	1.10	.14	Tr.	Tr.	Tr.	.75	.07	.20	[b]2.96	.83	9.12
1910	1.60	.70	.08	.30	0	0	.51	0	.39	.31	.36	1.23	5.48
1911	1.47	.40	.32	1.40	1.20	.46	.47	0	.10	.10	.20	.80	6.92
1912	.20	.20	1.00	2.90	.20	......	.15	.20	.20	1.11	.06	.30	......
1913	.27	.05	.38	.56	.41	2.53	1.64	.37	.67	Tr.	.90	.78	8.56
1914	.55	.25	......	Tr.	.25	1.25	.10	0	.15	1.49	Tr.	......	......
1915	.30	.67	.20	2.40	1.51	0	.02	Tr.	Tr.	Tr.	.10	.02	5.22
1916	1.40	.72	.52	Tr.	Tr.	0	0	0	......	......	......	......	......
Mean of the 35 complete records													6.97

[a] U. S. Weather Bur. Bull. W, section 12, pp. 2–3.

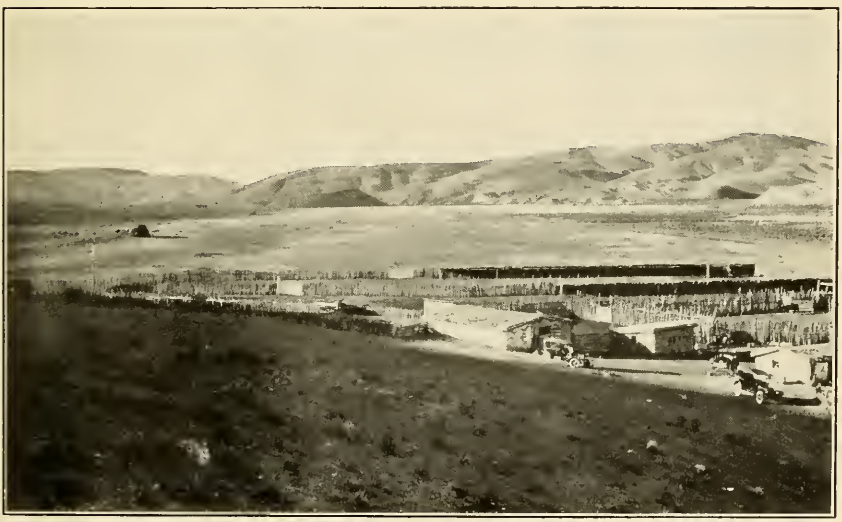
[b] Interpolated.

SURFACE WATER.

Reese River is supplied chiefly by its headwaters in the upper slopes of the Toyabe Range. It has no large tributaries, and most of the creeks that drain its narrow basin sides are dry during the summer. Like many other streams of the arid regions, the river itself alternately rises and sinks during the dry season. Near its headwaters the river is perennial; but not far below the point where it enters the valley the water is diverted into several irrigation ditches, and its channel becomes dry during most summers for a stretch of 6 or 7 miles between the Derringer and Bowler ranches. A short distance above the Bowler ranch the water reappears in small amount, and downstream it gradually increases in volume. The reappearing underflow is considerably augmented by water from a group of springs at the Whaley ranch. The flow is again diverted and used in irrigation on the Walsh Hess ranch, and below the alfalfa fields and native hay meadows of this ranch the channel is usually dry for about 10 miles, to the vicinity of the Gondolfo ranch. There the underflow reappears in several groups of springs and is in part again diverted for irrigation, but most of it is allowed to sink in the river channel, and during the later part of summer the water seldom flows as far north as Boone Creek. The river channel from Boone Creek to Humboldt River is dry throughout the summer.

A record of the flow of Reese River has been obtained by the United States Geological Survey at a gaging station on the upper course of the river about 1½ miles below Archie Bell's ranch and about 7 miles east of Berlin. The gage is a vertical staff on the left bank in the SW. ¼ sec. 16, T. 12 N., R. 40 E., about 75 yards above Illinois Creek and 100 yards above the headgate of the upper Bell

A. VALLEY OF BOONE CREEK, LOOKING DOWNSTREAM FROM MRS. LITSTER'S RANCH.



B. SPRING 1⅓ MILES SOUTHWEST OF ANTELOPE SPRING, IN ANTELOPE VALLEY.

ditch. The drainage area is 94 square miles. The observer is Roy Bell. The daily and monthly discharge from June 10, 1913, to September 30, 1916, are given in the following tables:

Daily discharge, in second-feet, of Reese River above Illinois Creek for the years ending Sept. 30, 1913–1916.

Day.	June.	July.	Aug.	Sept.	Day.	June.	July.	Aug.	Sept.
1913.					1913.				
1	....	6	4	84	16	9.4	4	4	2.5
2	....	6	4	173	17	7.1	4	4	8.2
3	....	6	4	45	18	8.2	4	4	4
4	....	6	4	4	19	8.2	4	4	10
5	....	5	4	4	20	8.2	10.5	4	4
6	....	5	4	4	21	6	8.2	4	2.5
7	....	5	4	4	22	6	2	8.2	8.2
8	....	5	4	4	23	7.1	4	4	6
9	....	6.7	4	4	24	6	4	4	4
10	19	6	4	4	25	6	4	6	4
11	19	4	4	4	26	8.2	4	8.2	4
12	13	4	4	4	27	20	4	6	2.5
13	13	4	4	6	28	19	4	8.2	4
14	14	4	4	6	29	14	4	10	4
15	12	4	4	4	30	12	4	6	4
					31	....	4	4	......

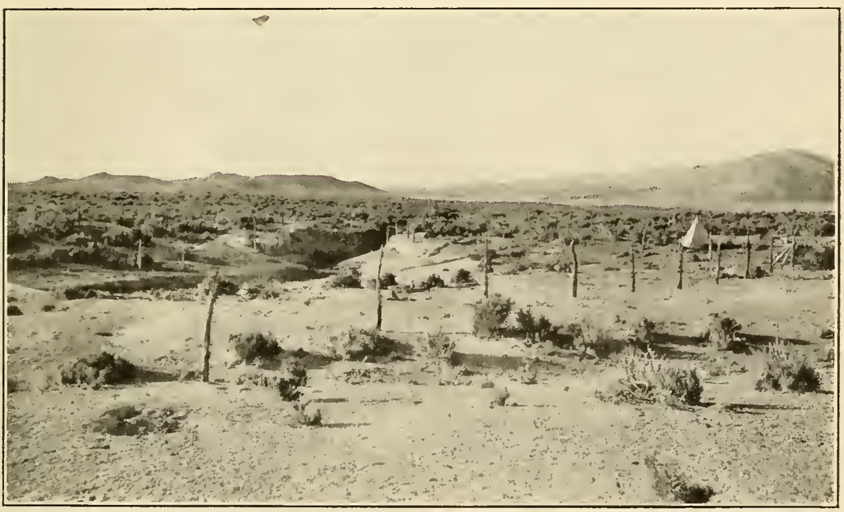
Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1913–14.												
1	4.0	4.0	4	6	......	6	19	64	130	26	11	6.3
2	4.0	2.5	4	6	......	8	19	60	138	26	11	6.3
3	4.0	2.5	4	6	......	10	25	130	130	24	9.6	6.3
4	4.0	2.5	4	8	......	8	40	130	122	22	8.5	6.3
5	4.0	2.5	4	8	......	8	44	130	126	22	8.5	6.3
6	2.5	2.5	4	8	......	8	40	122	122	21	8.5	6.3
7	2.5	2.5	......	8	......	9	44	114	122	21	8.5	6.3
8	1.7	2.5	......	8	......	10	40	122	114	21	8.5	7.4
9	1.7	2.5	......	......	......	16	40	122	100	21	8.5	6.3
10	2.5	4.0	......	......	......	22	40	122	87	21	8.5	6.3
11	4.0	4.0	......	......	......	25	40	130	82	21	8.5	6.3
12	2.5	2.5	......	......	......	29	40	122	76	20	8.5	6.3
13	2.5	2.5	......	......	......	29	40	130	76	20	9.6	6.3
14	2.5	2.5	......	......	......	32	48	138	68	20	9.6	6.3
15	2.5	4.0	......	......	......	36	48	130	63	18	8.5	6.3
16	2.5	6.0	......	......	......	44	52	154	63	18	8.5	6.3
17	2.5	4.0	......	......	......	40	72	146	55	20	8.5	6.3
18	2.5	4.0	......	......	......	40	57	138	51	20	8.5	6.3
19	2.5	4.0	......	......	......	44	48	130	51	32	8.5	6.3
20	2.5	4.0	......	......	36	44	67	150	53	40	6.3	6.3
21	2.5	2.5	......	......	25	44	57	158	53	55	6.3	5.2
22	2.5	2.5	......	......	13	48	48	166	47	20	6.3	7.4
23	2.5	2.5	......	......	9	48	52	162	45	16	11	7.4
24	2.5	4.0	......	......	6	44	57	154	40	15	8.5	8.5
25	2.5	2.5	......	......	4	52	52	138	36	14	7.4	9.6
26	2.5	2.5	......	......	2.5	52	57	122	32	14	6.3	11
27	4.0	6.0	......	......	6	57	52	100	51	14	5.2	7.4
28	2.5	6.0	4	......	6	52	62	106	32	14	5.2	7.4
29	2.5	6.0	5	......	......	19	60	110	32	14	6.3	7.4
30	2.5	4.0	6	......	......	19	64	106	30	12	6.3	7.4
31	2.5	......	6	......	......	19	......	138	......	12	6.3	......

Daily discharge, in second-feet, of Reese River above Illinois Creek for the years ending Sept. 30, 1913–1916—Continued.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1914–15.												
1	5.5	7.0	......	......	......	7.0	28	69	118	35	17	......
2	5.5	7.0	......	......	......	7.0	28	62	128	35	17	......
3	5.5	7.0	......	......	......	8.0	28	62	128	35	16	......
4	5.5	7.0	......	......	......	8.0	30	62	128	36	16	......
5	5.5	7.0	......	......	......	8.0	31	65	118	36	14	......
6	5.5	7.0	......	......	......	7.0	32	69	101	35	14	......
7	5.5	7.0	......	......	......	7.0	34	71	86	35	14	......
8	5.5	7.0	......	......	......	7.0	34	71	69	34	......	......
9	5.5	7.0	......	......	......	7.0	34	73	69	31	......	......
10	5.5	7.0	......	......	......	7.0	34	69	69	27	......	1.7
11	5.5	......	......	......	......	7.0	34	73	67	25	......	1.5
12	5.5	......	......	......	......	7.0	34	73	67	21	......	2.3
13	4.5	......	......	......	......	7.0	37	69	67	21	......	2.3
14	3.5	......	......	......	......	11	40	73	62	20	......	2.3
15	5.5	......	......	......	......	11	42	73	62	20	......	2.5
16	5.5	......	......	......	......	12	43	78	60	20	......	2.7
17	5.5	......	......	......	......	12	59	80	59	19	......	2.7
18	5.5	......	......	......	......	13	57	73	58	19	......	2.3
19	5.5	......	......	......	......	12	65	73	56	19	......	2.3
20	7.0	......	......	......	......	12	65	69	54	21	......	2.7
21	7.0	......	......	......	......	12	62	65	52	22	......	2.7
22	5.0	......	......	......	......	13	62	62	51	22	......	2.5
23	5.0	......	......	......	......	13	62	65	50	21	......	2.7
24	6.0	......	......	......	......	13	65	69	48	21	......	2.7
25	7.0	......	......	......	......	13	65	78	47	20	......	3.1
26	7.0	......	......	......	......	13	62	78	47	19	......	3.1
27	7.0	......	......	......	......	13	65	78	47	19	......	3.1
28	9.0	......	......	......	......	25	62	78	40	18	......	3.1
29	7.0	......	......	......	......	25	69	88	37	17	......	3.1
30	7.0	......	......	......	......	28	65	101	36	17	......	3.1
31	7.0	......	......	......	......	30	......	105	......	17	......	......
1915–16.												
1	3.1	......	......	......	......	......	......	......	36	11	3.5	3.1
2	3.1	......	......	......	......	......	......	......	40	12	3.5	2.9
3	3.1	......	......	......	......	......	......	......	37	12	3.5	2.7
4	2.9	......	......	......	......	......	......	......	39	11	3.5	2.5
5	3.1	......	5.5	......	......	......	......	......	41	8.5	3.5	2.5
6	3.1	......	4.5	......	......	......	......	......	43	7.6	3.5	2.5
7	2.9	5.5	4.5	......	......	......	......	65	44	8.0	3.5	1.9
8	3.1	5.5	5.1	......	......	......	......	64	47	8.5	3.5	1.7
9	3.1	5.5	5.1	......	......	......	......	63	46	7.9	3.5	1.5
10	3.9	5.5	5.3	......	......	......	......	60	46	8.5	3.5	1.9
11	4.7	5.5	5.3	......	......	......	......	58	47	8.5	3.5	2.0
12	5.5	5.5	......	......	......	......	......	56	46	11	3.5	2.2
13	5.5	5.1	......	......	......	......	......	54	46	12	3.5	2.3
14	5.5	4.7	......	......	......	......	......	52	40	10	3.5	2.1
15	5.3	4.7	......	......	......	......	......	50	40	8.5	3.5	1.9
16	5.1	4.3	......	......	......	......	......	49	40	8.5	3.5	1.9
17	5.1	4.1	......	......	......	......	......	48	33	8.5	3.5	2.3
18	5.1	4.3	......	......	......	......	......	48	26	7.9	3.5	2.3
19	......	3.9	......	......	......	......	......	48	19	8.5	3.5	2.3
20	......	3.5	......	......	......	......	......	48	24	8.5	3.1	2.5
21	......	5.1	......	......	......	......	......	48	23	8.5	3.1	2.7
22	......	5.1	......	......	......	......	......	47	22	7.9	3.1	2.7
23	......	5.3	......	......	......	......	......	48	21	7.3	3.0	2.7
24	......	5.1	......	......	......	......	......	48	20	6.7	2.9	2.3
25	......	5.5	......	......	......	......	......	48	19	5.9	2.9	2.7
26	......	5.1	......	......	......	......	......	47	19	5.5	2.8	3.1
27	......	5.5	......	......	......	......	......	44	12	5.1	2.7	2.6
28	3.5	5.5	......	......	......	......	......	40	12	5.5	3.1	2.0
29	......	5.5	......	......	......	......	......	40	12	4.5	3.1	1.5
30	......	5.5	......	......	......	......	......	39	12	3.5	3.1	1.5
31	......	......	......	......	......	......	......	36	......	3.5	3.1	......

NOTE.—Discharge estimated as follows: Dec. 7–27, 1913, 3 second-feet; Jan. 9–31 and Feb. 1–19, 1914, 5 second-feet; Aug. 8–31, 1915, 10 second-feet; Sept. 1–9, 1915, 3.4 second-feet; Oct. 19–27, 1915, 4.3 second-feet; Oct. 29–31, 1915, 3.8 second-feet; Nov. 1–6, 1915, 4.9 second-feet; Dec. 1–4, 1915, 5.5 second-feet. No records obtained Nov. 11, 1914, to Feb. 28, 1915, and Dec. 12, 1915, to May 6, 1916.

A. HEAD OF REESE RIVER CANYON, SHOWING TERTIARY LAKE BEDS ON EACH SIDE.



B. REESE RIVER VALLEY, LOOKING DOWNSTREAM FROM JAMES LITSTER'S RANCH; TERTIARY LAKE BEDS ON THE RIGHT.

Monthly discharge of Reese River above Illinois Creek near Berlin, Nev., for the years ending Sept. 30, 1913–1916.

Month.	Discharge in second-feet.			Run-off (total in acre-feet).
	Maximum.	Minimum.	Mean.	
1913.				
June 10–30	20	7.1	11.2	467
July	10.5	4.0	4.89	301
August	10	4.0	4.80	295
September	173	2.5	14.2	845
The period				1,910
1913–14.				
October	4	1.7	2.79	172
November	6	2.5	3.47	206
December	6		3.48	214
January	8		5.58	343
February	36	2.5	7.23	402
March	57	6	29.7	1,830
April	72	19	47.5	2,830
May	166	60	127	7,810
June	138	30	74.2	4,420
July	55	12	21.1	1,300
August	11	5.2	8.1	498
September	11	5.2	6.86	408
The year	166	1.7	28.2	20,400
1914–15.				
October	9.0	3.5	5.89	362
November 1–10	7.0	7.0	7.0	139
March	30	7.0	12.1	744
April	69	28	47.6	2,830
May	105	62	73.4	4,510
June	128	36	69.4	4,130
July	36	17	24.4	1,500
August	17		11.2	689
September		1.5	2.84	169
1915–16.				
October	5.5	2.9	4.09	251
November	5.5	3.5	5.01	298
December 1–11	5.5	4.5	5.21	114
May 7–31	65	36	49.9	2,220
June	47	12	31.7	1,890
July	12	3.5	8.08	497
August	3.5	2.7	3.31	204
September	3.1	1.5	2.29	136

Measurements of the discharge of Reese River at several points made by the writer in September, 1916, and by L. W. Jordan in June, 1917, are given in the following table:

Miscellaneous discharge measurements of Reese River at several points.

Date.	Point of measurement.	Discharge in second-feet.
1916.		
Sept. 6	Mouth of canyon a few yards above Bell's ditch	2.67
6	Gaging station 75 yards above mouth of Illinois Creek	2.34
8	East of J. F. Bowler's house	.22
8	6 miles north of Whaley ranch	5.16
11	Welch's home ranch	Dry.
11	Tony Gondolfo's house	.55
11	Road bridge on Lincoln Highway west of Austin	2.90
13	Malloy's lower ranch	1.23
13	Mouth of Silver Creek; water flowing to head of field about ½ mile above mouth of creek.	Dry.
13	3 miles above mouth of Boone Creek (water from Bradley and Watercress springs)	.05
13	Mouth of Boone Creek	Dry.
	Thence dry for the remainder of its course.	
1917.		
June 13	SW. ¼ sec. 16, T. 12 N., R. 40 E., just above mouth of Illinois Creek, 2 miles above the Bell home ranch	58.0
14	In T. 15 N., R. 41 E., 1,600 feet downstream from Lander-Nye County line, opposite lone butte about 25 miles south of Austin	134
14	In T. 20 N., R. 43 E., at first highway bridge across Reese River on the Austin-Battle Mountain road near the Malloy ranch and 8 to 10 miles from Austin (water comes from marshy land 5 to 10 miles above and is very brackish)	22.0
14	At mouth of Boone Canyon, 50 to 60 miles south of Battle Mountain (stream is dry at this point in years of average run-off)	5–10

NOTE.—In June, 1917, Reese River was flowing into Humboldt River at Battle Mountain.

The principal streams in the basin are, from north to south, Mill, Fish, Boone, Silver, Big, Clear, and Stewart creeks. In September, 1916, all these streams were carrying water for some distance below the mouths of their canyons.

A record of the flow of Big Creek has been obtained by the United States Geological Survey at a gaging station half a mile above the Carter ranch and 14 miles southwest of Austin. The gage used was a vertical staff on the left bank 100 yards above the head gate of Carter's ditch, in sec. 9, T. 17 N., R. 43 E. The drainage area is about 12 square miles. The observer was Mae M. Carter. The daily and monthly discharges from October 12, 1913, to June 30, 1914, are given in the following tables:

Daily discharge, in second-feet, of Big Creek half a mile above Carter ranch, near Austin, Nev., for the period Oct. 12, 1913, to June 30, 1914.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.
1	....	4.3	4.1	4.1	4.1	4.1	4.1	5.7	8.4
2	....	4.1	4.1	4.1	4.1	4.1	4.3	5.7	8.4
3	....	4.1	4.1	4.1	4.1	4.1	4.5	6.0	8.4
4	....	4.1	4.1	4.1	4.1	4.1	4.7	6.0	8.4
5	....	4.1	4.1	4.1	4.1	4.1	4.9	6.0	8.4
6	....	4.1	4.1	4.1	4.1	4.1	5.1	6.0	9.0
7	....	4.1	4.1	4.1	4.1	4.1	5.2	6.0	10.8
8	....	4.1	4.1	4.1	4.1	4.1	5.4	8.4	9.6
9	....	4.1	4.1	4.1	4.1	4.1	5.6	8.4	9.0
10	....	4.1	4.1	4.1	4.1	4.1	5.7	8.4	9.0
11	....	4.1	4.1	4.1	4.1	4.1	5.7	8.4	9.0
12	4.3	4.1	4.1	4.1	4.1	4.1	5.7	8.4	9.0
13	4.3	4.1	4.1	4.1	4.1	4.1	5.7	8.4	9.6
14	4.3	4.1	4.1	4.1	4.1	4.1	5.7	6.0	9.0
15	4.3	4.1	4.1	4.1	4.1	4.1	5.7	6.0	9.6
16	4.1	4.1	4.1	4.1	4.1	4.1	5.7	6.0	9.6
17	4.1	4.1	4.1	4.1	4.1	4.1	5.7	6.0	9.6
18	4.1	4.1	4.1	4.1	4.1	4.1	5.7	6.0	9.6
19	4.1	4.1	4.1	4.1	4.1	4.1	5.7	8.4	9.6
20	4.1	4.1	4.1	4.1	4.1	4.1	5.7	6.0	9.6
21	4.1	4.1	3.9	4.1	4.1	4.1	5.7	6.0	9.6
22	4.1	4.1	3.9	4.1	4.1	4.1	5.7	7.2	9.0
23	4.1	4.1	3.9	4.1	4.1	4.1	5.7	8.4	9.6
24	4.1	4.1	3.9	4.1	4.1	4.1	5.7	8.4	10.2
25	4.1	4.1	3.9	4.1	4.1	4.1	5.7	8.4	9.6
26	4.1	4.1	3.9	4.1	4.1	4.1	5.7	8.4	9.6
27	4.1	4.1	3.9	4.1	4.1	4.1	5.7	6.0	9.6
28	4.1	4.1	3.9	4.1	4.1	4.1	5.7	6.0	9.6
29	4.1	4.1	3.9	4.1	....	4.1	6.0	6.0	9.0
30	4.1	4.1	3.9	4.1	....	4.1	6.0	6.0	9.6
31	....	4.1	3.9	4.1	....	4.1	....	10.8	....

Monthly discharge of Big Creek half a mile above Carter ranch, near Austin, Nev., for the period Oct. 12, 1913, to June 30, 1914.

Month.	Discharge in second-feet.			Run-off (total in acre-feet).
	Maximum.	Minimum.	Mean.	
October 12–31	4.3	4.1	4.14	165
November	4.3	4.1	4.11	245
December	4.1	3.9	4.02	247
January	4.1	4.1	4.10	252
February	4.1	4.1	4.10	228
March	4.1	4.1	4.10	252
April	6.0	4.1	5.47	325
May	10.8	5.7	7.03	432
June	10.8	8.4	9.30	553
The period	....	....	....	2,700

Humboldt River carries only a small amount of water late in summer. The principal stream, besides Reese River, that is tributary to the Humboldt within the area shown on Plate VIII is Rock Creek.

A record of the flow of Rock Creek has been obtained by the United States Geological Survey at a point about 1½ miles above the Rock Creek ranch house, 9 miles northwest of Dunphy, and about 35 miles north of Battle Mountain. The gage used was a vertical staff near the left end of an old footbridge about a mile above the diversion dam at the mouth of the canyon, approximately in sec. 1, T. 37 N., R. 46 E. The drainage area has not been measured. The observer was W. H. Muffley. The daily and monthly discharges for May 13 to Sept. 30, 1915, are given in the following tables:

Daily discharge, in second-feet, of Rock Creek at Rock Creek ranch, near Battle Mountain, Nev., for the period May 13 to Sept. 30, 1915.

Day.	May.	June.	July.	Aug.	Sept.	Day.	May.	June.	July.	Aug.	Sept.
1		15	1.5	4.4	3.6	16	8.8	13			5.6
2		15	1.5	4.7	3.6	17	8.1	12	6.7		
3		15	1.5	5.0	3.6	18	10	12			
4		14	1.0	5.3	3.6	19	13	11			
5		13	.4	5.6	3.6	20	15	7			
6		13	.4	5.8	4.0	21	17	2.7			
7		13	.4	6.0	4.2	22	15	3.6			
8		13		6.2	4.4	23	13	4.4			
9		12		6.4	4.4	24	14	4.4			
10		11		6.7	4.4	25	16	4.4	4.4		
11		12		6.7	4.4	26	17	3.6	4.4		
12		13		6.7	4.4	27	16	3.3	4.4		
13	12	13		6.7	4.4	28	15	3.0	4.4		
14	11	13			4.8	29	14	2.7	4.4	3.6	
15	9.5	13			5.2	30	12	2.1	4.4	3.6	
						31	11		4.4	3.6	

NOTE.—Discharge estimated as follows: July 8–16, 3.5 second-feet; July 18–24, 5.6 second-feet; Aug. 14–28, 5.2 second-feet; Sept. 17–30, 5 second-feet.

Monthly discharge of Rock Creek at Rock Creek ranch, near Battle Mountain, Nev., for the period May 13 to Sept. 30, 1915.

Month.	Discharge in second-feet.			Run-off (total in acre-feet).
	Maximum.	Minimum.	Mean.	
May 13–31	17	8.1	13.0	491
June	15	2.1	9.57	569
July	6.7	.4	3.71	228
August	6.7	3.6	5.32	327
September	5.6	3.6	4.61	274
The period				1,890

Miscellaneous discharge measurements made by the writer during the reconnaissance are given in the following table:

Miscellaneous discharge measurements in Reese River and Humboldt River basins, Nev., 1916.

Date.	Stream and locality.	Discharge in second-feet.
Sept. 6	Bell's ditch 300 yards below its intake from Reese River	0.8
6	Stewart Creek at Schmaling's ranch	.2
6	Stewart Creek 3 miles above Schmaling's ranch	.6
6	Clear Creek at Gooding's ranch	.2
6	Silver Creek at upper (eastern) road crossing	.20
13	Boone Creek at Mrs. Litster's ranch	.15
13	Boone Creek at Boone Creek ranch	.10
14	Fish Creek at Fish Creek ranch	.60
15	Mill Creek at mouth of its canyon	.20
15	North Fork of Mill Creek 25 yards above its junction with South Fork	.15
15	South Fork of Mill Creek 25 yards above its junction with North Fork	.30
20	Humboldt River at road crossing 1½ miles southwest of Kampos	1.75
21	Rock Creek at bridge at mouth of its canyon	.30
21	Rock Creek 1 mile above the bridge	.80

SOURCE AND DISCHARGE OF GROUND WATER.

Practically all the ground water of the Reese River valley is derived from the precipitation within the drainage basin. The bedrock constitutes a relatively water-tight basin, which is deeply filled with unconsolidated deposits in which the ground water is stored. Some water is supplied to this underground reservoir directly by the precipitation on the valley lands, but the greater part is supplied by the run-off through the numerous canyons, whose water rapidly sinks in the loose materials of the alluvial slopes below the canyon mouths.

The contributions of water to the underground supply are offset by losses through percolation out of the basin, through evaporation and transpiration from moist areas, and through discharge of springs.

The underground percolation from the Reese River valley to Humboldt Valley is probably slight, because the gradient of the lower part of the Reese River valley is low.

In the areas of appreciable discharge through evaporation where the water table is within the capillary limit[1] of about 10 feet below the surface the evidence of constant evaporation is usually shown by the dampness of the ground, by alkaline deposits, or by the growth of certain plants, chiefly salt grass and various bushes. Ground water is less than 10 feet below the surface of nearly all the cultivated land in the Reese River basin. These lands are devoted chiefly to growing native hay, but there are a few fields of alfalfa. Along Humboldt River, however, much of the native-hay land is irrigated by ditches from the river, and the ground water

[1] Lee, C. H., An intensive study of the water resources of a part of Owens Valley, Cal.: U. S. Geol. Survey Water-Supply Paper 294, 1912. Meinzer, O. E., Geology and water resources of Big Smoky, Clayton, and Alkali Spring valleys, Nev.: U. S. Geol. Survey Water-Supply Paper 423, pp. 92–102, 1917.

is shown by wells to be at a somewhat greater depth than the probable limit of appreciable discharge through evaporation. The areas both of cultivated land and of ground-water discharge through capillarity are shown on Plate VIII (in pocket).

There are not many springs in the drainage basin of Reese River. Most of them are in the mountains and are supplied by rain and snow water from the adjacent slopes. Some of the springs in the lowlands, such as Mound Spring, the hot springs east of Fish Creek, and the hot springs in Buffalo Valley, are probably supplied by deep-seated water that rises along fault fractures and does not represent leakage from the valley fill. Antelope Spring and the springs southwest of it (see Pl. VIII, in pocket, and Pl. XI, *B*) and Bradley and Watercress springs seem to be supplied by water stored in materials of the Truckee formation, above the valley lowlands. Buffalo and Kane springs, in Buffalo Valley, are apparently supplied by water under artesian pressure stored in the alluvial slopes at the base of the Havallah Range. A spring (No. 12 on Pl. VIII) in the lowland southwest of Battle Mountain seems to be supplied from the water table, at a place where the ground surface is depressed a few feet below its mean level. The springs along the river channels near Tony Gondolfo's ranch, in the valley above Austin, represent the return of the underflow to the surface. The springs at Whaley's ranch issue from the alluvial slope on the west side of the lowland and discharge water stored in the unconsolidated material.

WATER TABLE.

Practically all the wells in the area at the time of examination are shown on Plate VIII. Except at Battle Mountain, where there are about 40 small flowing wells, enough wells have not been sunk on the slopes bordering the lowlands to ascertain the depth to water beneath these slopes. The valley areas within which the water table is less than 10 feet below the surface are shown on Plate VIII, and the depth to water in the wells examined is indicated.

From the shallow-water areas the water table rises toward the mountains on a grade considerably less than that of the surface, so that the depth to water increases rapidly with increased elevation above the lowlands. The only measurement obtained that affords definite information as to the slope of the water table was that of the well at the O'Toole ranch (No. 83 on Pl. VIII). The depth to water there is 80 feet, and the mouth of the well is about 130 feet above the lowland near the river, a mile to the west, where the depth to water is about 10 feet. The water table in this vicinity therefore seems to rise to the east at the rate of 60 feet to the mile, having a gradient about half as steep as that of the surface of the ground. The slope of the water table in different parts of the basin depends on the sup-

ply of ground water, the slope of the surface, and the character of the material in which the water occurs. The single observation given can not be applied indiscriminately to other parts of the basin.

QUANTITY OF GROUND WATER.

Studies of the amount of ground-water intake were not made by measurements of the perennial and intermittent streams, nor of the ground-water discharge by a survey and detailed examination of the areas where the water table is within 10 feet of the surface. Neither are figures at hand to show the depth and porosity of the valley fill. Any numerical estimate of the total amount of ground-water stored in the valley fill of the Reese River basin would therefore seem to be a mere guess. As the annual supply of surface water is not sufficient to make the river perennial, even in the upper half of its course, the annual intake of ground water must be comparatively small, though records of drilled wells indicate that the valley fill is several hundred feet deep and therefore has large storage capacity. Test wells show that the materials are prevailingly fine grained, however, and that the rate at which water can be recovered by pumping is slow.

The depth to water is less in the upper part of the Reese River valley, south of the Reese River canyon, than it is in the lowlands north of the canyon. The amount of available ground water is therefore presumably greater in the upper part of the valley than in the lower part. Antelope Valley probably contains a relatively small amount of ground water, for its drainage basin is small and its lowland seems dry. Buffalo Valley receives considerable water from the high slopes of the Havallah Range and from the drainage basin that extends northward between Battle Mountain and the Havallah Range. It apparently has a more plentiful supply of ground water than Antelope Valley, and its water table is less than 10 feet below the surface in the lowest part of the valley.

ARTESIAN CONDITIONS.

In the town of Battle Mountain drilled or bored wells that yield artesian flows under small head furnish the water supply. In 1916 43 flowing wells were reported in the town and vicinity. There are said to be four horizons of flowing water, at about 100, 180, 250, and 300 feet below the surface. The greatest static head encountered is reported to have been about 16 feet above the surface. The artesian head has declined noticeably since the Southern Pacific Co. drilled a deep well in the town and has been pumping large quantities of water from it to supply locomotives. On the north side of Humboldt River four flowing wells (Nos. 2, 3, 4, and 18, Pl. VIII), were drilled prior to 1904, and in 1916 each of these was flowing a few

gallons a minute. On the Jenkins Martin ranch, 9 miles south of Battle Mountain, there were three wells that barely flowed.

In the Reese River valley above the canyon several wells have been drilled in attempts to develop artesian flows to supply stock-watering troughs. A well (No. 56) drilled 210 feet deep near the border of the lowland, 1½ miles north of Boone Creek, struck water under slight artesian head, sufficient to bring it within 3 feet of the surface, or about 8 feet above the ground-water level. On James Litster's ranch a casing sunk 15 feet into a small spring (No. 54) yields a slight flow, and in 1916 a well was being drilled a few yards from it, in an attempt to obtain a larger flow. A well (No. 63) drilled near Bradley Springs yields a small flow. On the Walsh home ranch a flow of 8 gallons a minute was obtained at about 450 feet. On W. S. Carter's desert claim a 200-foot well (No. 78) obtained a flow of 10 gallons a minute, but another well 505 feet deep, drilled on the same tract, failed to strike flowing water. Fred Ahlers has two wells (Nos. 80 and 81) 6 feet apart and 107 and 110 feet deep. The shallower one yields a slight flow. In the other the water stands 2 feet below the surface. On the Walsh Hess ranch a well was drilled 860 feet deep in an unsuccessful attempt to develop a flow.

Above the Reese River canyon the prospects of obtaining flowing wells are best in the lowlands near the river, as shown by the success of the well at the Walsh home ranch and to a less extent by that on W. S. Carter's desert claim. The Ahlers wells seem to be at about the eastern limit of artesian flow. The wells drilled in this part of the valley encountered only clay and very fine sand, the flows being obtained from a fine black sand. None of the wells encountered coarse material that might readily yield water.

In the places along the Reese River valley where extensive alluvial slopes exist small supplies of flowing water can probably be obtained by wells put down along the lower margins of these slopes. It seems improbable that the underflow of Reese River itself develops sufficient head to yield artesian flows. The underflow of Big Creek and adjacent canyons probably supplies the Carter and Ahlers flowing wells and also the one at Walsh's home ranch. Flows can probably be obtained along the east border of the lowlands between Italian Creek and Watercress Springs, on the west border near Fish Creek, on the east side between Mill Creek and Crum Creek, and near the playa in Antelope Valley. In Buffalo Valley Buffalo Springs and Kane Springs seem to be supplied by water under artesian pressure below the alluvial slopes to the west. In the vicinity of Battle Mountain and probably along the valley of Humboldt River above and below this town flowing water under a small static head can doubtless be obtained over a much greater area than is at present outlined by flowing wells.

Throughout the Reese River basin and adjacent portions of the Humboldt basin the artesian head is small and the water-bearing beds consist largely of fine sand. The prospects of developing flowing wells of large yield are therefore not encouraging.

QUALITY OF GROUND WATER.

GENERAL CHARACTER.

Analyses of samples of water from wells and springs in the Reese River basin (see table, pp. 125-129) show that the waters are quite as good as those in other valleys of the arid West. Although the grade of Reese River is not great and its discharge is small, the basin as a whole is well enough drained to prevent the accumulation of alkali in the valley lands. Most of the waters are satisfactory for domestic use and for irrigation, but more than half of those examined would form excessive quantities of scale or cause foaming in boilers.

The water from most of the drilled wells is more satisfactory for ordinary uses than that obtained from shallow dug wells, and the water obtained from springs is apparently poorer than that from the deep wells but better than that from the shallow wells. This relation is shown by the following table:

Average, maximum, and minimum content of chemical constituents in water from dug wells, drilled wells, and springs.

[Parts per million exce t as otherwise designated.]

	Dug wells (21).			Springs (6).			Drilled wells (9).[a]		
	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.
Silica (SiO_2)	40	67	17	60	117	35	39	73	17
Iron (Fe)	.03	.30	.02	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.
Calcium (Ca)	64	125	21	60	123	30	60	157	23
Magnesium (Mg)	17	42	6.7	9.3	36	10	18	52	Tr.
Sodium and potassium (Na+K)[b]	131	587	32	123	327	16	32	50	2.8
Carbonate radicle (CO_3)	14	168	.0	2.3	14	.0	9.5	38	.0
Bicarbonate radicle (HCO_3)	304	793	107	392	761	129	222	670	44
Sulphate radicle (SO_4)	111	601	20	86	227	22	56	89	24
Chloride radicle (Cl)	78	557	16	28	50	16	25	84	6.0
Nitrate radicle (NO_3)	19	80	.0	1.0	6.0	.0	.0	.0	.0
Total dissolved solids at 180°C	638	2,133	281	580	1,032	252	370	694	235
Total hardness as $CaCO_3$ [c]	229	394	80	188	455	75	223	606	58
Scale-forming constituents [c]	260	420	130	250	460	180	250	580	120
Foaming constituents [c]	350	1,600	90	330	880	43	87	140	8
Alkali coefficient (inches) [c]	23	79	24	30	100	2.5	100	290	19
Depth of well (feet)	26	108	7	......	....	......	254	500	25
Depth to water (feet)	20	80	6	......	....	......	([d])	16	([d])

[a] Well No. 54 omitted; sample contained vegetable matter; water probably of surface origin.
[b] Calculated.
[c] See standards for classification given in U. S. Geol. Survey Water-Supply Paper 398, pp. 50-81, 1916.
[d] Seven of the nine drilled wells are flowing.

WATER FROM DUG WELLS.

The effect of evaporation and transpiration, the processes that tend to concentrate natural waters, is shown in the analyses mainly by the greater amount of total dissolved mineral matter, most of which consists of the more soluble salts, for the less soluble salts are more readily precipitated. As a net result, therefore, of evaporation and transpiration the water remaining in the ground contains relatively more of the alkalies and less calcium and magnesium than water not thus concentrated. As these processes are active at the surface of the ground, the water of many shallow wells contains large amounts of sodium and potassium, carbonate, bicarbonate, sulphate, and chloride and is therefore high in total solids.

The content of total solids in the water from dug wells in the Reese River basin ranges from 281 to 2,133 parts per million; the average is 638 parts. The proportions of calcium and magnesium are relatively large, as would be expected from the fact that the rocks of the region are calcareous, but in many of the waters the alkalies greatly exceed the alkaline earths. Carbonate is present in the water of 8 of the 21 dug wells, and in that of one of the wells it amounts to 168 parts per million. The content of bicarbonate ranges from 107 to 793 parts per million, averaging 304 parts. Sulphates and chlorides are high in some of the waters, but in only a few are they present in excess of other acid radicles.

The presence of organic matter in excessive amounts is worthy of mention. Nitrate is normally absent from ground waters or is present in only small amounts, for rocks as a rule contain only traces and soils but little more. The nitrate in these well waters is probably derived from decayed organic matter and indicates pollution by sewage, which may seep from near-by barnyards, privies, or cesspools through the ground and into the wells, or may fall into the wells through open tops or through covers that are not water-tight and dirt-proof. Many shallow wells are thus contaminated, and if analyses of waters from such wells show that nitrate amounts to more than a few parts per million the sanitary conditions surrounding the wells should be carefully examined, possible sources of pollution should be removed, covers should be so fitted that waste water will drain away from rather than into the well, and farm animals should be kept at a safe distance.

Most of the waters are of the carbonate type, ten (Nos. 5, 37, 43, 50, 72, 74, 82, 83, 85, and 98) being calcium-carbonate and eight (Nos. 6, 7, 8, 20, 46, 55, 66, and 87) sodium-carbonate. Of the three remaining, two (Nos. 34 and 49) are sodium-chloride waters and one (No. 32) is a calcium-sulphate water.

Six of the waters (Nos. 32, 34, 37, 49, 66, and 72) have been classed as bad for domestic use, chiefly because of their hardness but partly because they contain excessive amounts of chloride and sulphate.

The other fifteen (Nos. 5, 6, 7, 8, 20, 43, 46, 50, 55, 74, 82, 83, 85, 87, and 98) range in quality from fair to good for drinking and cooking, so far as mineral content is concerned, though they may be polluted, as has been suggested in connection with the discussion of nitrate. None of the waters can be classed as good for use in boilers, and only four (Nos. 7, 20, 87, and 98) have been classed as fair; the rest (Nos. 5, 6, 8, 32, 34, 37, 43, 46, 49, 50, 55, 66, 72, 74, 82, 83, 85, and 98) are poor or very bad, for they contain in too great amount constituents that cause incrusting and foaming, and the water of one well (No. 32), if used for making steam, would probably corrode the boiler.

Although many of these waters are not satisfactory for domestic supplies or for use in boilers, most of them can be used for irrigation without danger to crops from deposition of alkali. Three of the waters (Nos. 34, 49, and 55) are classed as poor for irrigation, but the first two are sodium-chloride waters that would probably leave in the soil the less injurious "white alkali," and the third is a sodium-carbonate water which might leave "black alkali" upon evaporation. This water (No. 55) might be used to grow some of the crops more resistant to alkali if carefully applied to land that had been treated with gypsum and was adequately drained.

WATER FROM SPRINGS.

Analyses of samples of water from six springs in this area apparently indicate that the spring waters are not so highly mineralized as the water from dug wells, the average content of total solids in water from springs being 580 parts per million, whereas the average for water from dug wells is 638 parts per million. The average content of silica and bicarbonate is higher in the spring waters than in the water from the dug wells, but that of the other constituents is lower. The water of only one spring (No. 90) is reported to contain nitrate, and that water only 6.0 parts per million, an amount that is small when compared with such an amount as 80 parts per million in the water of the shallow dug wells (p. 114).

The waters of three of the springs (Nos. 24, 60, and 90) are calcium-carbonate, and three (Nos. 41, 47, and 48) are sodium-carbonate in character. The water of well 24 has been classed as bad for domestic use because of its hardness (455 parts per million), but the other five (Nos. 41, 47, 48, 60, and 90) are fair or good for drinking and cooking. In general they are not well suited for use in boilers, though the water from springs 60 and 90 would form in boilers only a moderate amount of soft scale.

Two of the spring waters (Nos. 41 and 48) contain such quantities of alkalies as to be unsatisfactory for use for irrigation unless on lands that are exceptionally well drained. The water from spring 41

is not now used for irrigating crops, but that from spring 48, although used for irrigation, is likely to cause trouble if precautions are not taken to prevent accumulation of alkali in the soil. Water from the other four springs (Nos. 24, 47, 60, and 90) is better adapted for use in irrigating.

WATER FROM DRILLED WELLS.

Samples of water from ten drilled wells in the area covered by this report were analyzed. Eight of the wells exceed 100 feet in depth; two (Nos. 39 and 54) are 25 and 15 feet deep, respectively. Although No. 54 is a drilled well the water from it is evidently derived from surface run-off or from material lying little below the surface, for it is totally unlike that from other drilled wells, contains much mineral matter, largely alkalies and bicarbonate, is only fair for domestic use, and could not be used satisfactorily in boilers or for irrigation without special precautions. The analysis has therefore not been included with the others in the table on page 114.

In almost all the analyses of the water from drilled wells the averages of constituents (table, p. 114) are lower than those shown by analyses of the water from dug wells. This statement is especially true of the alkali (Na+K) and the acid radicles (CO_3, HCO_3, SO_4, Cl, and NO_3). In only one of the samples, that from the shallow well (No. 54) discussed above, was nitrate reported present. This apparent absence of the oxidation products of decayed organic matter gives considerable assurance that the waters from these drilled wells are free from contamination by sewage and are therefore safe for human consumption.

Six of the drilled wells (Nos. 17, 30, 39, 76, 78, and 80) yield calcium-carbonate waters, two (Nos. 4 and 22) sodium-carbonate waters, and the remaining well (No. 26) a sodium-sulphate water.

Only one of the nine waters averaged (that from well 80) is classed as bad for domestic use; the rest are either good or fair. Well 39, on the Indian ranch, is an exception to the rule that shallow wells are distinctly inferior to deeper ones, so far as quality of water is concerned. This well is only 25 feet deep, yet its water is but moderately mineralized, is fair for domestic use, and is good for irrigation; it might be satisfactorily used in boilers if no better supply were available, but if so used should be softened by treatment with lime.

The average content of total solids in the nine wells—370 parts per million—is decidedly lower than that for springs, which is 580 parts, and approximately 50 per cent of the average for dug wells, which is 638 parts per million.

SUMMARY OF QUALITY OF WATER.

1. Dug wells furnish water that is generally satisfactory, so far as mineral content is concerned, for domestic use, good or fair for irrigation, and poor for use in boilers. If the water is to be used for domestic supply, such wells must be carefully located and protected from pollution.

2. The water from springs is usually satisfactory for domestic use, poor for boilers, and better than that from dug wells for irrigation.

3. The deeper drilled wells, if properly cased to exclude water from near the surface, will yield water that is more satisfactory for general uses than either dug wells or springs.

WATER SUPPLIES.

DOMESTIC SUPPLIES.

Most of the residents in and near Battle Mountain are supplied from flowing wells 2 or 3 inches in diameter, but a few are supplied by shallow wells that tap only the superficial ground water. In the Reese River basin water on the ranches is obtained chiefly from shallow dug wells, but springs supply a few ranches, including the Wilson ranch (No. 24, Pl. VIII), the Hotspring ranch (No. 48), and the Warner ranch (No. 90). A few others, as the Fish Creek and Boone Creek ranches, are supplied by perennial streams.

PUBLIC SUPPLY.

The only public supply in the area is that of Austin. Water for this town is furnished by a spring on the higher slopes to the southeast and is piped down to a tank and a reservoir on a knoll in the town. Thence it is distributed through several lines of pipe. The yield of the spring was not learned, but it is said to be ample throughout the year for the needs of the town.

STOCK SUPPLIES.

In the mountains there are a few small springs that supply the range cattle in the later part of the summer, when most of the canyons become dry. In the lowlands Reese River furnishes the principal stock supply where its flow is perennial, and in the upper part of the valley flowing wells are obtained. In the lower part of the Reese River valley there is in summer a serious lack of watering places, however, and although there has been some attempt to overcome this lack by means of flowing wells, efforts to obtain flows have in most localities not proved successful. It seems probable that in the lower part of the Reese River valley pumped supplies must be relied upon, perhaps by the use of windmills. The water from flowing wells is exceptionally good stock water for winter use because it is comparatively warm and hence does not chill the animals.

INDUSTRIAL SUPPLIES.

Industrial supplies in the area were in 1916 limited to those used by the railroad companies. At Battle Mountain the Southern Pacific Co. has a 480-foot well and a pumping station which supplies the needs of locomotives and of cattle that are being shipped. The Western Pacific Railroad has a shallow dug well of large diameter at Kampos, which supplies the locomotives, and another shallow well of large diameter at Dunphy, where the watering of cattle being shipped on this line is in part done.

IRRIGATION FROM WELLS.

DEVELOPMENTS.

In 1916 irrigation from wells had been attempted in only two places in the area examined—on the desert claim of Ramón Oyarbide, 8 miles south of Battle Mountain, and on the desert claim of W. S. Carter, 8 miles southwest of Austin. Mr. Oyarbide had two small pumping plants, consisting of distillate engines and centrifugal pumps, lifting from the ground-water level, about 15 feet below the surface. Mr. Carter was depending on a flowing well for the irrigation of a portion of his claim. Both developments had been made only a short time, and no crop had been planted on either claim.

Although there are a number of flowing wells in the Reese River and Humboldt River basins, the examination indicates that the artesian head is small and that flows sufficient for irrigation probably can not be obtained. Irrigation with ground water must be accomplished chiefly by pumping.

WELL CONSTRUCTION.

Water can be easily obtained by digging wells in the lower parts of the Reese River and Humboldt River valleys, but such wells can not be cheaply sunk to depths very far below the water table, because of the necessity of curbing. Dug wells sunk only a short distance below the level at which water is struck can not furnish large supplies. Wells sunk to obtain artesian flows for domestic use or for stock or to obtain supplies for irrigation by pumping probably will have to be put down more than 100 feet.

Ordinary cable drilling rigs have been used with good results in sinking wells in this region. Hydraulic outfits, in which water is pumped down through hollow drill rods and comes up on the outside, bringing the drillings with it, are well suited for cheap, efficient, and rapid work in the deep, fine-grained, unconsolidated deposits of the Reese River and Humboldt River basins. In drilling by this method the ascending muddy water plasters the walls of the well and produces an effective coating. Even in a deep well in soft

materials it is generally not necessary to insert casing until drilling has been completed; and in some localities where the materials are clayey, casing of the lower part of the well is unnecessary. Hydraulic machines are much used for sinking wells 2 to 4 inches in diameter, and these could be put down cheaply in order to test the water supply prior to undertaking irrigation development. The machines are, however, too light for the efficient sinking of wells 6 inches or more in diameter, and wells of relatively large diameter are desirable for pumping supplies. The ordinary cable tools are probably best adapted to drilling wells for irrigation in this area.

For pump wells 6 inches in diameter or larger "stovepipe" casing of heavy sheet iron forms a very serviceable and relatively cheap casing. It is made of 2-foot sections, of two sizes, one of which slips snugly over the other, with the ends breaking joints. The casing is built up and forced down the well as drilling progresses. As casing of this kind leaks at the joints it is not suitable for use in flowing wells, in which the more expensive but water-tight screw casing must be used. In pump wells the casing should be perforated at every satisfactory water-bearing bed, either before or after the insertion of the casing in the well. Where flowing water is encountered in valley fill there are usually satisfactory artesian beds at two or more horizons, and in order to get the maximum yield all of them should be penetrated by the drill, and the casing should be perforated throughout the thickness of each artesian bed.

Quicksand does not seem to have been encountered in quantities so large as to seriously hinder drilling in wells that have been sunk in the area examined. The fine materials seem to consist of clay or sandy clay and to be easily handled by experienced drillers.

RECOVERY OF WATER.

The depth to which it is advisable to drill wells to be pumped for irrigation differs greatly from place to place, depending on the character of the valley fill. The available data indicate that along the borders of the Reese and Humboldt river valleys it probably will not be of advantage to sink more than 200 or 300 feet. In the lower lands, near the troughs of the valleys, sufficient water for small pumping plants can probably be obtained from wells less than 200 feet deep, if they are properly cased and perforated. In places where coarse water-bearing material is obtained at shallow depths two or more relatively shallow drilled wells may yield a larger total supply than one deep well. For economy in pumping, wells that are near each other are usually connected to the same pump.

Care should be taken to insure as large a recovery as possible from each well by perforating the casing at every suitable water-bearing bed with as many and as large perforations as is practicable, and

in finishing the well to clean it thoroughly by strong pumping in order to remove the fine sediments and thus produce a strainer of gravel and coarse sand around the casing. Large yields keep down the cost of well construction per unit of water developed and, by lessening the drawdown, keep down the cost of lifting water.

Horizontal centrifugal pumps are generally used in areas where the pumping lift is not great, and as the ground-water level is at shallow depths throughout most of the lowlands of the Reese River and Humboldt River valleys such pumps will doubtless prove best adapted to raise water for irrigation in this region. The pump should be set in a pit just above the water level, so as to work under as low a suction lift as possible, and the size of the pump should be carefully chosen with respect to the capacity of the well. Care should also be taken that the discharge from the pump is no higher than is necessary, for the power required for pumping depends on the height to which the water is lifted, and the cost of power is one of the largest costs in irrigation by pumping.

For the Reese River basin, where electric power is not available for pumping, distillate or oil engines are probably the most suitable power units. The cost of pumping depends largely on the efficiency of the pumping plant, and after the size of pump best adapted to the capacity of the well and the pumping lift has been determined the engine should be properly chosen with respect to it. An engine that is larger than is necessary to run the pump or one that is too small to run the pump at proper speed will make the cost of pumping needlessly high. Most of the manufacturers of pumping machinery have in their service experts who will assist farmers in planning installations suitable to the local conditions of ground water and the irrigation development that is to be undertaken.

AREAS.

The lands that seem to be best adapted to irrigation by wells in the upper part of the Reese River valley are along the east side between Big Creek and Austin. Farther up and down the valley and also along the west side the soil is composed to a large extent of clay, probably derived from the Truckee formation, and is of poorer quality than the alluvial material along the bases of the fans of Big Creek and adjacent canyons. Much of the meadow land along the river between the Walsh Hess ranch and Ledlie could probably be made more productive than it is at present by following irrigation with flood water by irrigation with pumped water. The land in the lower part of the Reese River valley, along the east side, below the Hotspring ranch, although covered largely with an unpromising growth of arid-land shrubs, can be made productive by irrigation, as is shown by a large alfalfa field, irrigated by stream water at the

Jenkins home ranch. The lands near the river channel are so barren as to make it unwise to attempt irrigation unless careful tests show that both the soil and the ground water available for irrigation are so free from alkali that it will not cause trouble. Antelope Valley is rather barren, but there may be a supply of ground water of sufficient purity for use in irrigation within easy pumping reach. The lower part of Buffalo Valley is an alkali-incrusted flat, but the gentle slopes that border it on the west and north are probably underlain by water of fair quality within 50 feet of the surface; and pumping irrigation might be developed to a considerable extent on these lands. Along the valley of Humboldt River shallow water is available for pumping, and in some places this water can doubtless be advantageously developed for irrigation as auxiliary to the surface-water supply.

CROPS AND MARKETS.

The short growing season, with cold spring and autumn, limits the variety of crops that can be grown in the region, and the lack of transportation facilities in parts of the area examined also places restrictions on the kinds of crops that can be profitably grown. Austin and Battle Mountain furnish only small markets for such hardy vegetables as can be grown. The chief agricultural interest is directly related to stock raising, principally of cattle, and alfalfa promises to be the most profitable irrigated crop, to be grown for local use as winter feed.

WELLS AND SPRINGS.

The following list is believed to include all the important springs and nearly all the wells, except some of those in Battle Mountain, that had been sunk at the time the region was examined. The figures giving the depth to the water table at each well probably show with fair accuracy the depth to water in the vicinity of the well. It should be noted that the figures indicate the depths to the water table, which is not the same as the depth to water in the wells because the water in some of the deeper wells is under considerable artesian head. The chemical composition and classification of such of these waters as were analyzed are shown on the pages facing those giving the general information concerning the same waters.

Data concerning wells and springs in Reese River basin and adjacent parts of Humboldt River basin, Nev.

General information.

No. on Pl. VIII.	Location. T. N.	Location. R. E.	Owner of well or name of spring.	Depth to water table.[a]	Depth of well.	Diameter of well.	Yield of well.[b]	Temperature of water.	Use of water.	Remarks.
				Feet.	*Feet.*	*Inches.*	*Gallons per min.*	*°F.*		
1	33	43	Ames Spring				2			
2	33	45	Land Development Co	15	400	6	5		Stock	Artesian flow struck at about 300 feet.
3	33	45	do	12	375	6	10	57	do	Do.
4	33	45	do	15	375	6	1	56	Domestic and stock	Artesian flow struck. See analysis.
5	33	47	Western Pacific R. R	6	10				Locomotives	Dug. 15 feet in diameter. See analysis.
6	33	47	Dunphy estate	11	15			58	Domestic	Dug. See analysis.
7	33	48	Western Pacific R. R	14	20			53	Cattle trains	Do.
8	33	48	Dunphy estate	15	20				Domestic	Do.
9	32	41	Summit Springs				3			
10	32	44	Tony Lonjero	12	15				Domestic	Dug.
11	32	44	F. B. Starr	14	20	18			do	Do.
12	32	44	Spring							
13	32	45	John Hare	12	15				Domestic	Do.
14	32	45	John Paul	12	400	6	5		Domestic and stock	Three wells. Artesian flows struck near bottom.
15	32	45	Southern Pacific Co	13	480	6			Locomotives	Slight artesian flow.
16	32	45	Jenkins Bros	11	400	6	10		Domestic	Artesian flow struck near bottom.
17	32	45	Land Development Co	12	300	6	10		Domestic and stock	Three wells. Artesian flows. See analysis.
18	32	45	do	15	300	6			Stock	Artesian flow.
19	32	45	do	13	60	6			Domestic and stock	Pumping plant.
20	32	45	James Blossom	12	15				do	Dug. See analysis.
21	32	45	Samuel Broyle	11		6	5		do	Two wells. Artesian flows.
22	32	45	Farris ranch	15	190	6	5	65	do	Artesian flow. See analysis.
23	32	46		12					Stock	Dug.
24	31	43	Spring at Wilson ranch				25		Domestic	See analysis.
25	31	44		78	83				Roadside watering	Dug.
26	31	45	Jenkins Martin ranch	12	500	6	½		Stock	Artesian flow. See analysis.
27	31	45	do	20	500	6	½		Domestic and stock	Two wells. Artesian flows.
28	31	45	Ramón Oyarbide	14	130	6			Domestic	Irrigation planned.
29	31	45	do	15	135	6				Do.
30	31	45	do	16	140	6				Pumping plant. Irrigation planned. See analysis.
31	31	45	—— Peale	12	34				Domestic	Dug. Pumping plant. Irrigation planned.
32	31	46	Charia ranch	74	77				Domestic and stock	Dug. Windmill. See analysis.
33	30	41	Buffalo Springs				5		Irrigation	
34	30	42	"Picketts Well"	7	10				Roadside watering	See analysis.

[a] In wells with artesian head the water rises in the well above the level indicated.

[b] The yield given for flowing wells is the natural flow.

Chemical composition and classification of waters.

[Samples collected by G. A. Waring; analyzed by S. C. Dinsmore; parts per million except as otherwise designated.]

No. on Pl. VIII.	Determined quantities.											Computed quantities.[a]				Classification.[a]					
	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).[b]	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Chloride radicle (Cl).	Nitrate radicle (NO_3).	Total dissolved solids at 180° C.	Total hardness as $CaCO_3$.	Scale-forming ingredients (s).	Foaming ingredients (f).	Alkali coefficient (inches).	Mineral content.	Chemical character.	Probability of corrosion.[c]	Quality for boiler use.	Quality for domestic use.	Quality for irrigation.
4	73	Tr.	23	Tr.	47	38	76	24	6.0	0.0	250	58	140	130	19	Moderate .	Na–CO_3	N....	Fair.......	Good..	Good.
5	40	Tr.	54	18	55	.0	259	49	46	.0	426	209	230	150	34	...do.......	Ca–CO_3	N....	Poor.......	Fair...	Do.
6	50	0.05	72	Tr.	100	.0	366	52	30	.0	486	180	260	270	9.7	...do.......	Na–CO_3	N....	...do.......	...do...	Fair.
7	35	Tr.	48	13	75	.0	275	59	35	.0	429	173	200	200	17	...do.......	...do....	N....	Fair.......	...do...	Do.
8	47	.10	50	23	172	9.6	454	94	75	.0	697	219	230	460	6.2	High......	...do....	N....	Very bad .	...do...	Do.
17	70	Tr.	40	11	35	.0	142	45	41	.0	340	145	210	90	47	Moderate..	Ca–CO_3	(?)	Poor.......	Good..	Good.
[d]20	56	Tr.	30	7.0	50	.0	193	32	14	.0	300	104	160	140	21	...do.......	Na–CO_3	N....	Fair.......	...do...	Do.
22	65	Tr.	30	1.0	50	.0	162	30	17	.0	298	79	160	140	21	...do.......	...do....	N....	...do.......	...do...	Do.
24	35	Tr.	123	36	82	.0	398	227	50	.0	750	455	460	220	31	High......	Ca–CO_3	(?)	Bad.......	Bad...	Do.
26	20	Tr.	33	Tr.	44	19	44	67	28	.0	235	82	120	120	57	Moderate..	Na–SO_4	(?)	Fair.......	Good..	Do.
30	20	Tr.	51	20	43	29	160	87	23	.0	387	210	200	120	64	...do.......	Ca–CO_3	(?)	...do.......	Fair...	Do.
32	25	Tr.	70	31	77	7.2	129	187	66	80	624	302	280	210	27	High......	Ca–SO_4	C.....	Poor.......	Bad...	Do.
34	23	Tr.	31	27	488	168	317	264	307	.0	1,388	188	160	1,300	2.4	...do.......	Na–Cl.	N....	Very bad .	...do...	Poor.

[a] See standards for classification in U. S. Geol. Survey Water-Supply Paper 398, pp. 50–81, 1916.
[b] Calculated.
[c] C=corrosive; N=noncorrosive; (?)=corrosion uncertain or doubtful.
[d] Aluminum (Al), trace.

Data concerning wells and springs in Reese River basin and adjacent parts of Humboldt River basin, Nev.—Continued.

General information.

No. on Pl. VIII.	Location. T. N.	Location. R. E.	Owner of well or name of spring.	Depth to water table.[a]	Depth of well.	Diameter of well.	Yield of well.[b]	Temperature of water.	Use of water.	Remarks.
				Feet.	*Feet.*	*Inches.*	*Gallons per min.*	*°F.*		
35	30	43	—— Lee	8	10				Unused	Dug.
36	30	43	do	6	8				Stock	Do.
37	30	44	Jenkins home ranch	35	60				Domestic and stock	Dug. Windmill. See analysis.
38	29	40	Buckbrush Spring				2			
39	29	41	Indian ranch	11	25	18			Domestic	See analysis.
40	29	41	Kane Springs				10		Irrigation	
41	29	41	Hot Springs				5	*c* 130	Unused	Do.
42	29	43	Childress Bros	15	25				do	Dug.
43	29	43	do	40	45				Domestic and stock	Dug. Small pumping plant. See analysis.
44	28	44	Mound Springs				3	*c* 110	Roadside watering	
45	27	43	Fish Creek ranch	65	67					Dug. Abandoned.
46	27	43	Nevada Central R. R	5	10				Railroad	Dug. See analysis.
47	27	43	Hot springs				450	124	Irrigation	See analysis.
48	27	43	do				50	122	Domestic and irrigation	Do.
49	26	43		24	25				Unused	Dug. See analysis.
50	25	41	Cottonwood ranch	24	27				Domestic	Do.
51	25	43	Nevada Central R. R		81					Dug. Dry.
52	25	43		20	22				Unused	Dug.
53	24	40	Cone Springs				10			
54	24	43	James Litster	3	15	6		102	Bathing	See analysis.
55	24	43	do	6	10				Domestic	Dug. See analysis.
56	23	43	—— Philippi	11	210	6			Unused	Artesian water stands in well 3 feet below surface.
57	23	43	Nevada Central R. R	6	10				Railroad	Dug.
58	22	40	Spring				½			
59	22	40	do				½			
60	22	40	do				1		Stock	See Plate IV, *B;* also analysis.
61	22	41	Antelope Spring				2		do	
62	22	43	Bradley Springs				3		Unused	
63	22	43	—— Philippi	5	200	6	1		do	Artesian flow.
64	22	43	Watercress Springs				3		do	
65	21	42	Spring				1		do	
66	21	42	Malloy home ranch	6	8				Domestic	Dug. See analysis.
67	21	43	Nevada Central R. R	6	15				Railroad	Dug.
68	20	43	Malloy upper ranch	6	7				Domestic	Do.
69	19	41	Spring				½			

a In wells with artesian head the water rises in the well above the level indicated, *b* The yield given for flowing wells is the natural flow. *c* Maximum.

Chemical composition and classification of waters.

[Samples collected by G. A. Waring; analyzed by S. C. Dinsmore; parts per million except as otherwise designated.]

No. on Pl. VIII.	Determined quantities.											Computed quantities.[a]				Classification.[a]					
	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).[b]	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Chloride radicle (Cl).	Nitrate radicle (NO_3).	Total dissolved solids at 180° C.	Total hardness as $CaCO_3$.	Scale-forming ingredients (s).	Foaming ingredients (f).	Alkali coefficient (inches).	Mineral content.	Chemical character.	Probability of corrosion.[c]	Quality for boiler use.	Quality for domestic use.	Quality for irrigation.
37	22	0.10	125	20	85	0.0	400	100	67	64	675	394	420	230	26	High......	$Ca-CO_3$	(?)	Poor......	Bad...	Good.
39	32	Tr.	75	14	38	.0	212	34	84	.0	413	245	280	100	24	Moderate..	...do....	(?)	...do......	Fair...	Do.
41	117	Tr.	30	Tr.	327	.0	761	109	34	.0	1,032	75	210	880	2.5	High......	$Na-CO_3$	N....	Very bad .	...do...	Poor.
43	17	Tr.	104	25	109	.0	346	172	78	32	735	362	360	290	21	...do.......	$Ca-CO_3$	(?)	Poor......	...do...	Good.
46	28	Tr.	40	10	100	.0	251	48	72	.0	428	141	160	270	12	Moderate .	$Na-CO_3$	N....	Bad	Good .	Fair.
47	41	Tr.	65	10	121	.0	447	63	24	.0	559	204	250	330	7.7	High......	...do....	N....	Poor......	Fair...	Do.
48	55	Tr.	64	Tr.	154	.0	468	74	23	.0	627	160	240	420	5.8	...do.......	...do....	N....	Very bad-.	...do...	Poor.
49	46	.30	85	41	587	17	185	601	557	80	2,133	381	360	1,600	3.2	Very high.	Na-Cl .	(?)	...do......	Bad...	Do.
50	20	Tr.	80	12	52	.0	251	33	49	64	455	249	280	140	30	Moderate .	$Ca-CO_3$	(?)	Poor......	Fair...	Good.
54	42	Tr.	64	5.0	268	.0	768	77	34	5.0	863	180	240	720	2.9	High......	$Na-CO_3$	N....	Very bad .	...do...	Poor.
55	41	Tr.	69	Tr.	280	.0	793	74	34	6.0	905	172	240	760	2.8	...do.......	...do....	N....	...do......	Bad ..	Do.
60	67	Tr.	32	10	16	.0	129	23	18	.0	252	121	180	43	100	Moderate..	$Ca-CO_3$	(?)	Fair......	Good..	Good.
66	57	Tr.	76	37	174	24	439	211	71	.0	918	342	340	470	11	High......	$Na-CO_3$	N....	Very bad .	Bad...	Fair.

[a] See standards for classification in U. S. Geol. Survey Water-Supply Paper 398, pp. 50–81, 1916.
[b] Calculated.
[c] C=corrosive; N=noncorrosive; (?)=corrosion uncertain or doubtful.

Data concerning wells and springs in Reese River basin and adjacent parts of Humboldt River basin, Nev.—Continued.

General information.

No. on Pl. VIII.	Location. T. N.	Location. R. E.	Owner of well or name of spring.	Depth to water table.[a]	Depth of well.	Diameter of well.	Yield of well.[b]	Temperature of water.	Use of water.	Remarks.
				Feet.	*Feet.*	*Inches.*	*Gallons per min.*	*°F.*		
70	19	44	Spring						Supply for Austin	Piped to tank above town.
71	18	42	....do				100	52	Irrigation	
72	18	42	Tony Gondolfo	5	7			46	Domestic	Dug. See analysis.
73	18	42	Springs				50		Irrigation	
74	18	42	Margaret Ryan	6	10				Domestic	Do.
75	18	42		7	8				Unused	Dug.
76	18	42	Walsh home ranch	6	450	8	8	59	Stock	Artesian flow. See analysis.
77	18	43	W. S. Carter	30	505	6			Unused	Artesian water rises within 7 feet of surface.
78	18	43	....do	30	200	6	10	52		Artesian flow. Irrigation planned. See analysis.
79	18	43	....do		25					Dug. Dry.
80	18	43	Fred Ahlers	40	107	6	1		Domestic	Artesian flow. See analysis.
81	18	43	....do	40	110	6			Unused	Artesian water stands in well 2 feet below surface.
82	16	42	Walsh Hess ranch	15	20				Domestic	Dug. Windmill. See analysis.
83	16	42	O'Toole ranch	80	108				Domestic and stock	Dug. See analysis.
84	15	41	J. J. Whaley (springs)				50		Irrigation	
85	14	41	J. F. Bowler	11	15				Domestic	Do.
86	13	40	Spring				1			
87	13	40	J. F. Schmaling	12	20			48	Domestic	Do.
88	13	42	Spring				2			
89	12	40	....do				10		Irrigates small garden	
90	11	40	O. C. Warner (spring)				75	63	Domestic and irrigation	See analysis.
91	11	40	Spring				1			
92	11	40	....do				½			
93	11	40	....do				½			
94	11	40	....do				½			
95	11	40	....do				½			
96	11	40	....do				1			
97	11	40	Keough home ranch	6	10				Domestic	Dug.
98	11	40	Keough upper ranch	8	12				....do	Dug. See analysis.
99	10	40	Spring				10			

a In wells with artesian head the water rises in the well above the level indicated.

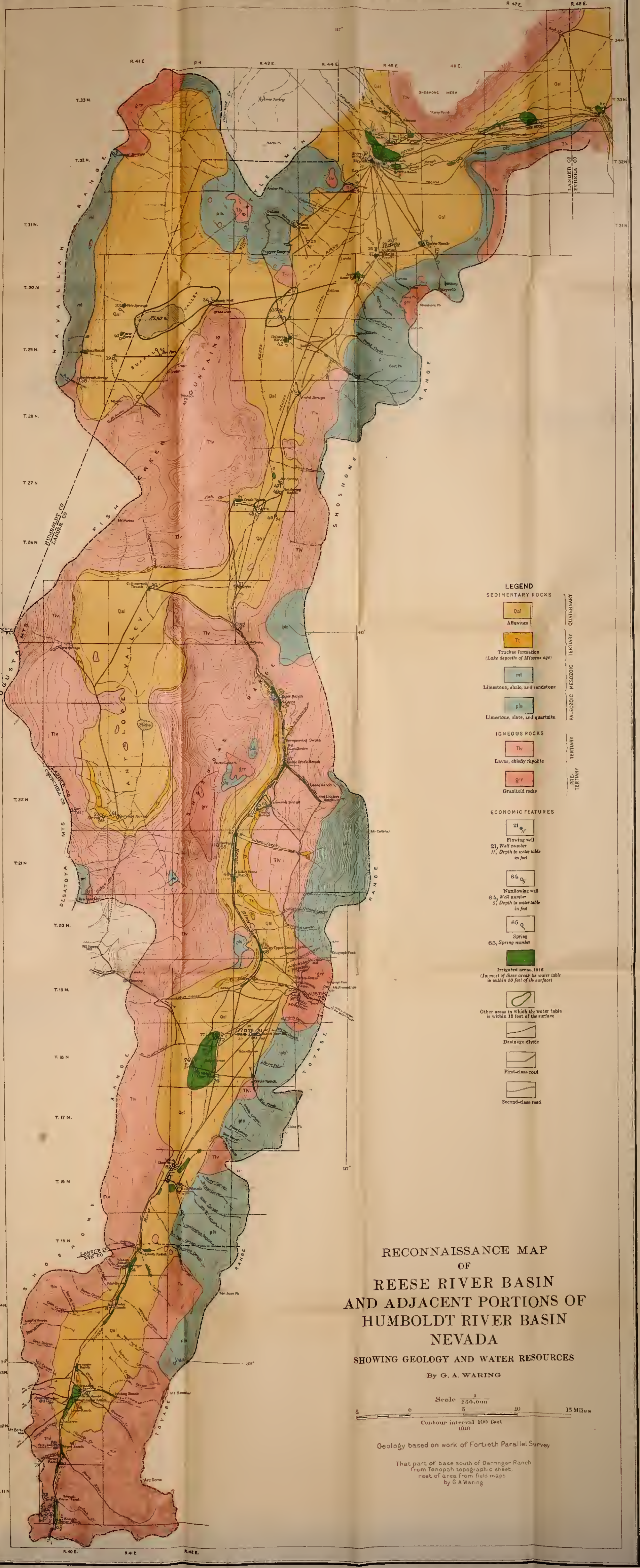
b The yield given for flowing wells is the natural flow.

Chemical composition and classification of waters.

[Samples collected by G. A. Waring; analyzed by S. C. Dinsmore; parts per million except as otherwise designated.]

No. on Pl. VIII.	Determined quantities.											Computed quantities.[a]				Classification.[a]					
	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).[b]	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Chloride radicle (Cl).	Nitrate radicle (NO_3).	Total dissolved solids at 180° C.	Total hardness as $CaCO_3$.	Scale-forming ingredients (s).	Foaming ingredients (f).	Alkali coefficient (inches).	Mineral content.	Chemical character.	Probability of corrosion.[c]	Quality for boiler use.	Quality for domestic use.	Quality for irrigation.
72	54	Tr.	75	42	66	14	417	109	17	0.0	590	360	340	180	48	High	$Ca-CO_3$	N	Poor	Bad	Good.
74	37	Tr.	67	15	46	.0	310	40	23	.0	410	229	260	120	31	Moderate	do	N	do	Fair	Do.
76	22	Tr.	64	35	4.5	.0	273	75	8.0	.0	369	304	270	12	260	do	do	(?)	do	do	Do.
[d]78	17	Tr.	65	28	2.8	.0	261	57	7.0	.0	345	277	260	8	290	do	do	(?)	do	do	Do.
80	33	Tr.	157	52	22	.0	670	89	8.0	.0	694	606	580	60	160	High	do	(?)	Bad	Bad	Do.
82	44	Tr.	84	Tr.	32	12	212	55	20	.0	366	210	290	90	79	Moderate	do	(?)	Poor	Fair	Do.
83	67	Tr.	64	10	62	.0	237	64	17	64	468	201	270	170	23	do	do	(?)	do	do	Do.
85	39	0.02	51	14	41	.0	237	41	27	.0	368	185	210	110	45	do	do	N	do	Good	Do.
87	60	Tr.	21	6.7	57	.0	205	21	10	.0	309	80	130	150	15	do	$Na-CO_3$	N	Fair	do	Fair.
90	48	Tr.	45	Tr.	37	14	146	22	16	6.0	261	112	180	100	30	do	$Ca-CO_3$	N	do	do	Good.
98	40	Tr.	48	Tr.	41	46	107	20	16	.0	281	120	180	110	24	do	do	N	do	do	Do.

[a] See standards for classification in U. S. Geol. Survey Water-Supply Paper 398, pp. 50–81, 1916.
[b] Calculated.
C=corrosive; N=noncorrosive; (?)=corrosion uncertain or doubtful.
[d] Aluminum (Al), trace.


RECONNAISSANCE MAP
OF
REESE RIVER BASIN
AND ADJACENT PORTIONS OF
HUMBOLDT RIVER BASIN
NEVADA
SHOWING GEOLOGY AND WATER RESOURCES
By G. A. WARING
Scale 1/250,000
5 0 5 10 15 Miles
Contour interval 100 feet
1918
Geology based on work of Fortieth Parallel Survey
That part of base south of Derringer Ranch from Tonopah topographic sheet, rest of area from field maps by G. A. Waring
LEGEND
SEDIMENTARY ROCKS
Qal Alluvium QUATERNARY
Tt Truckee formation (Lake deposits of Miocene age) TERTIARY
mf Limestone, shale, and sandstone MESOZOIC
pls Limestone, slate, and quartzite PALEOZOIC
IGNEOUS ROCKS
Tlv Lavas, chiefly rhyolite TERTIARY
grr Granitoid rocks PRE-TERTIARY
ECONOMIC FEATURES
Flowing well
21, Well number
11, Depth to water table in feet
Nonflowing well
64, Well number
5, Depth to water table in feet
Spring
65, Spring number
Irrigated areas, 1916 (In most of these areas the water table is within 10 feet of the surface)
Other areas in which the water table is within 10 feet of the surface
Drainage divide
First-class road
Second-class road
SHOSHONE RANGE
TOYABE RANGE
DESATOYA MTS
AUGUSTA MTS
HAVALLAH RANGE
FISH CREEK MOUNTAINS
ANTELOPE VALLEY
BUFFALO VALLEY
BATTLE MTN
SHOSHONE MESA
HUMBOLDT CO
LANDER CO
CHURCHILL CO
NYE CO
EUREKA CO
AUSTIN